SCIENCE ABSTRACTS.

Section A.—PHYSICS.

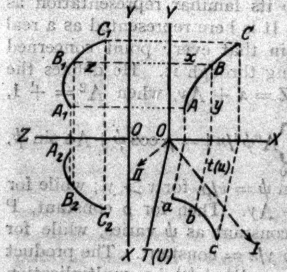
APRIL 1923.

GENERAL PHYSICS.

415. *Demonstration of Fresnel's Law of Ether Drag Without Recourse to the Relativity of Time and Space.* **C. Raveau.** (Comptes Rendus, 175. pp. 613–615, Oct. 16, 1922.)—The demonstration of Fresnel's formula now presented is based upon an interference apparatus in which one of the rays is made to traverse successively, but in opposed sense, a fluid in motion and the same fluid at rest. A second ray traverses a vacuum. The apparatus is considered when at rest and when driven at such a speed that the conditions of rest are preserved. For this purpose the Fresnel expression has to be satisfied. H. H. Ho.

416. *The Lorentz Transformation as a Real Hyperbolic Rotation.* **J. Spielrein.** (Archiv f. Elektrot. 11. pp. 230–237, Sept. 10, 1922.)—The author entitles his paper Vector Representation of the Lorentz Transformation, without any reference to its familiar representation as an imaginary rotation in the space-time. It is here represented as a real *hyperbolic rotation*, as it may be called, in that every point concerned moves along the hyperbola initially passing through it. He defines the position of a point P by the equation $Z = x + \Lambda y$, when $\Lambda^2 = +1$, and, further, writes $x + \Lambda y = \rho e^{\psi} = \rho \sum_{n=0}^{\infty} \Lambda^n \psi^n / n! = \rho \cos\psi + \Lambda\rho \sin\psi$, $\rho^2 = x^2 - y^2$, $\tan\psi = y/x$, $\cos\psi = x/\rho$, $\sin\psi = v/\rho$, for $x > y$; while for $x < y$, $\Lambda(y + \Lambda x)$ is substituted for $x + \Lambda y$. Then for ρ constant, P will move along a hyperbola $x^2 - y^2 =$ constant as ψ varies, while for ψ constant, P will move in a straight line $y/x =$ constant. The product $Z_1 Z_2 = x_1 x_2 + y_1 y_2 + \Lambda(y_1 x_2 + x_1 y_2) = \rho_1 \rho_2 e^{\Lambda(\psi_1 + \psi_2)}$, i.e. multiplication $e^{\Lambda\psi}$ indicates a hyperbolic rotation. If the x, y plane be projected into a u, v plane, so that there is one to one correspondence between the values u, v and x, y, then $W = u + \Lambda v$ will be an analytic function of x and y provided that $\partial^2 u/\partial x^2 = \partial^2 u/\partial y^2$ and $\partial^2 v/\partial x^2 = \partial^2 v/\partial y^2$, or, integrating, if $u + v = 2f(x + y)$ and $u - v = 2g(x - y)$, where f and g are arbitrary functions. It will then follow that $Z + M$ and MZ are analytic functions of Z, where $M = m + \Lambda n =$ constant. Moreover both the product and quotient of two analytic functions of a variable Z are analytic functions of Z. The author calls attention to these results as removing certain difficulties which would otherwise be encountered in demonstrating the convergence of certain power series occurring in the further development of his scheme. Measuring the time t by putting $y = ct$, when c is the light velocity, a motion along a straight line Ox will be determined in space and time by the coordinates x, y of a world-point P. For by means of the hyperbolic complex any point in the x, y plane will be defined by $Z = y + \Lambda x = \rho e^{\Lambda\psi}$, where for $y^2 > x^2$, $\rho^2 = c^2t^2 - x^2$, and $\tan\psi = x/y$, and for $x^2 > y^2$, $\rho^2 = x^2 - c^2t^2$ and $\tan\psi = y/x$. The asymptotes $x^2 - y^2 = 0$ divide the complex into two parts containing respectively the space-like and time-like vectors. For uniform motion along Ox with velocity v, $x/y = vt/ct = v/c = \beta = \tan\psi_1 =$ constant. The Lorentz transformation is that which reduces this motion to rest, by, viz. new coordinates x', $y' = ct$, for which the straight line OP is parallel to the y axis, and is given by $Z' = Ze^{-\Lambda\psi_1} = \rho e^{\Lambda(\psi - \psi_1)}$, or written at length, $x' = (x - \beta y)/(1 - \beta^2)^{\frac{1}{2}}$, $y' = (y - \beta x)/(1 - \beta^2)^{\frac{1}{2}}$. The converse transformation is $Z = Z'e^{\Lambda\psi_1} = \rho e^{\Lambda(\psi' + \psi_1)}$. For both the hyperbolic complex, $\rho =$ const., remains unchanged. This result is generalised by writing $dZ' = dZe^{-\Lambda\phi} = cd\tau$, where $d\tau$ is the proper time varying from point to point of the world-line. Einstein's addition theorem of velocities can be derived. The world-line of a point having constant rest-acceleration is also simply derived, and the directions of the velocity and acceleration are shown to be those of conjugate diameters of the hyperbola. Finally, the principal modifications required in the vector analysis are briefly indicated. G. W. DE T.

417. *Elementary Geometrical Representations in the Special Relativity Theory.* **P. Gruner.** (Zeits. f. Physik, 10. 1. pp. 22–37, 1922.)—This paper is a noteworthy development of the methods employed in a former paper [Abs. 30 (1922)]. The paper contains several interesting examples of the discussion of relativity problems by simple projective methods applied to the four-dimensional space-time. The key to the method is shown in the accompanying diagram. The projections ABC, $A_1B_1C_1$, $A_2B_2C_2$, of points upon a world line, on to the planes XY, YZ, ZX, are of the ordinary elementary geometrical type. The novelty consists of the combination with them of a fourth projection *abc* not rectangular, for there is no room for this, but oblique, XOT. In this the positive time axis is drawn downwards, OT(U), and this whole projection referred to as the under space. This enables the change of any space coordinate with the time, *e.g.*, according to equations of the form $x = f(t)$, $y = \phi(t)$, $z = \psi(t)$, to be dealt with by similar elementary projective methods. The straight world-lines I and II, which are the bisectors of the angle XOT, include those space points which at the time $t = 0$ start from the origin 0 and travel along the X-axis in both directions with the velocities 1 and − 1 respectively. G. W. DE T.



418. *Empirical Foundations of Restricted Relativity Theory.* **A. Schidlof.** (Arch. des Sciences, 4. pp. 333–342, Sept.–Oct., 1922.)—

If an ordinary coordinate system in uniform rectilinear motion be called a *Galilean System*, the fundamental principle of the restricted theory may be stated in the abstract form: At every time-space point and relatively to any Galilean reference system natural laws are of invariant form. It follows from this that equations expressing natural laws in terms of the time-space must be covariant with respect to some homogeneous linear transformation of x, y, z, t. But this does not lead necessarily to the Lorentz equations. For this involves the further condition that the metrical ground-form of the transformation should be of the form $x^2 + y^2 + z^2 - c^2t^2$, where c, the velocity of light *in vacuo*, is a constant parameter. For this reason Einstein adopted as the foundation of the theory, the following principle: The velocity of light *in vacuo* is constant, i.e. independent of the movement of the source. Stated in this form, the principle becomes immediately open to the test of experimental verification, and the author, starting with the discussion, in simple diagrammatic form, of the Michelson-Morley experiment, and concluding with Sommerfeld's introduction of the relativity correction into Bohr's dynamic model of the atom, and thereby accounting quantitatively for the fine structure of the spectra of H and He, shows that each of Lorentz's four equations is susceptible of complete experimental verification, and that in the present state of our knowledge the conclusions to which they lead are among the most firmly established experimental facts. G. W. DE T.

419. *Thermic and Dynamic Causes of Air Movement.* **F. M. Exner.** (Meteorolog. Zeits. 39. pp. 73–79, March, 1922.)—The thermal and dynamic causes of air currents, cyclones, and whirlwinds are discussed in connection with the meteorological work of Bigelow in America and of Wegener, Myrbach, Margules, and others in Europe. The important dynamic relation is $\frac{1}{2}dc^2 = - dp/\rho$, where c = speed of air, ρ = its density, and p = the pressure resulting from the motion. P. E. S.

420. *Vertical Atmospheric Velocity.* **B. Iswekow.** (Meteorolog. Zeits. 39. pp. 203–208, July, 1922.)—Owing to the unreliability of existing determinations of the vertical component of the wind, the hydrodynamical relations are here again examined from first principles. The investigation leads to two independent equations for the vertical component, each of which involves the horizontal components of the wind in a different way; and one equation can be used as a check. Numerical examples are given for observations taken at a height of 1000 m. at Lindenberg, 1911. Observations taken on the 7th Dec. give the following values for the vertical component—one for each equation—1·85 and 1·22 m. per sec. W. A. R.

421. *Temperature and Variations of Wind Velocity in Warm and Cold Cyclones.* **S. Hanzlik.** (Meteorolog. Zeits. 39. pp. 232–236, Aug., 1922.)—An analysis of the observations at 9 stations at various elevations with the object of finding the effects of warm and cold cyclones and the distribution of temperature under different conditions. The author is of opinion that the shallow eddies do not originate at the European seaboard, but that rather the high and cold eddies of the Atlantic region (where the meridional temperature gradient is small) move eastward towards the land masses (where the temperature gradient is steep) often to be transformed into warm eddies and renewed in vigour, to travel still further eastward and upward to become once more low-temperature eddies at considerable elevations. J. W. T. W.

422. *Atmospheric Turbidity.* **F. Linke** and **K. Boda.** (Meteorolog. Zeits. 39. pp. 161–166, June, 1922.)—Various formulæ for measuring atmospheric turbidity are reviewed, and Linke's modification of the Lambert-Bourget formula is considered in detail. It is suggested that a "turbidity factor" be used, and this is defined as the number of pure, dry atmospheres, which give the same absorption as the actual, turbid, and moist atmosphere. The turbidity factor shows a daily variation, and the investigations show that the greater the turbidity factor the greater its daily variation.

Solar Constant.—Their investigations lead the authors to believe that strong reasons can be raised against the reality of the interdiurnal variation of the solar constant; and that the apparent variations are due to changes in atmospheric turbidity. W. A. R.

423. *Theory of Halo.* **E. Maey.** (Meteorolog. Zeits. 39. pp. 229–231, Aug., 1922.)—A contribution to the theory of the halo formed by dew-drops. It is shown that the phenomenon can be explained by supposing the drops to have either of the forms shown in the diagram, so that total internal reflection causes a maximum brightness in the direction opposite to that of the incident light. J. W. T. W.

Fig. 1.

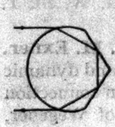


Fig. 2.

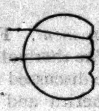
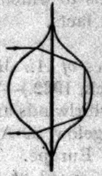


Fig. 3



424. *Thermoelectric Measurement of Nocturnal Variations of Temperature in the Lower Atmospheric Strata.* **K. Gehlhoff.** (Meteorolog. Zeits. 39. pp. 137–141, May, 1922.)—In this problem both radiation and convection are involved. As regards radiation, the efficient factors are: Nebulosity, atmospheric moisture, and the temperature of the ground and of the air strata after sunset. Convection is affected, further, by air currents, and therefore by wind force in various upper strata. The influence of all these factors has been investigated in recent years by Hellmann and Defant. The author's researches were supplementary to those investigations, and were directed to the examination of the formation of temperature inversion strata up to a height of 30 m. Continuous observation of the temperature fluctuations during the whole night and at different altitudes necessitated the employment of automatic registration. For this purpose the method of thermo-elements was chosen. A lengthy and detailed description is given of the apparatus used. Important meteorological influences were also noted. The moisture was registered by a thermo-hygrograph, and the wind force by three wind gauges at heights of 30 m., 12 m., and 2 m. respectively. The results obtained are shown in two tables of curves. It was found that at altitudes of 30 and 20 m. the temperature falls fairly uniformly till sunrise, and that at sunrise it rises in the upper, but falls in the lower strata. This seems to justify the conclusion that before convection sets in from below the upper strata are warmed by absorption of radiation. E. F.

425. *Rain and Snow on the Great St. Bernard.* **R. Gautier.** (Arch. des Sciences, 4. pp. 343–353, Sept.–Oct., 1922.)—During the last twenty years the determination of the heights of snow and of the corresponding snow water has been greatly perfected in the Alps by the use of totalisers permitting the accumulation of the aqueous deposits (rain and snow) for a whole year at elevated stations of difficult access and attainable only in summer. Forty totalisers are now installed, a large proportion at altitudes above 3000 m. The records obtained for some years past tend to modify previous estimates of the maximum altitude for aqueous deposits on a mountain. This altitude was formerly put at 2000 or 2500 m. and the maximum fall of water at about 2½ metres. It now seems probable that the maximum is reached at a much greater height and that it amounts to about 3 metres. This, if confirmed, would be a fact of prime importance for the economy of the régime of Alpine glaciers and streams. The meteorological station on the Great St. Bernard was founded in 1817, but it is only from 1818 onwards that the measurements of snow and rain have a scientific value. Since 1836 they have been made in centimetres and millimetres, but up to 1841 the totals are somewhat uncertain. According to the author's communications to the 9th International Geographical Congress (Geneva, July–Aug., 1908) on "The Temperature and Precipitations on the Great St. Bernard," the annual mean aqueous precipitation for 94 years (1818–1917 less 1836–1841) would be 1345 mm. But this figure is probably too high, and it is preferable to adopt that given for the period from 1864–1903 in the publication on the Swiss climate by Maurer, Bilwiller and Hess, namely 1278 mm. In the spring of 1917 a new "protected" pluviometer, of which an illustration is given, was installed on the Great St. Bernard. It is summarily described in these Archives, 1917, 43, p. 517 and 1918, 45, p. 374. The five years that have elapsed since its installation are insufficient for establishing means, but it is really only a question of calculating the relative values. The total deposits for this period are given in two tables. Speaking generally, it may be said that the measurements made with the new pluviometer show a mean annual deposit exceeding 1800 mm. of water in snow and rain. E. F.

426. *Meteorological Observations at Saint-Maurice.* **R. Gautier** and **E. Rod.** (Arch. des Sciences, 4. pp. 297–308, July–Aug., 1922.)—This is an annual summary of observations at various places. W. R. C.

427. *Determining Meteorological Periods.* **E. Rubinstein.** (Meteorolog. Zeits. 39. pp. 272–276, Sept., 1922.)—Meteorology has hitherto made little progress in the direction of predicting phenomena. Prominent among the problems whose solution conduces to this end is the question of periodicity. Owing to the complex nature of atmospheric phenomena this question is still in an initial stage of its development, and there seem to be, so far, no accurately determined periods. The methods of determination are not all theoretically sound, and often lack a general character. The author discusses the application of the method indicated by W. Schmidt in two articles in the Meteorolog. Zeits. in 1911 and 1913 on "Periods of Long Duration." The treatment of the subject is entirely mathematical. E. F.

428. *The 11-Year Temperature Period in Europe in its Relation to the Sunspot Period.* **F. Baur.** (Meteorolog. Zeits. 39. pp. 289–293, Oct., 1922.)—An investigation based on data supplied by 30 meteorological stations spread over a fairly wide area of North, West, and Central Europe, to which were added, by way of comparison, two tropical stations. The results were obtained by Fourier's analysis as being better for the purpose than the graphic method employed by Köppen and Mielke. Examination of the various phases of the 11-year temperature period shows that as latitude increases and the "continental" position becomes more perfect the temperature maximum shifts more and more from the normal tropical position towards the spot maximum. In Germany's winter temperatures, the course of the 11-year period corresponds with the higher latitudes, whereas in the summer temperatures it approximates more to the tropical or oceanic type. This points to the assumption that the relation of the 11-year temperature period to the sunspot period is determined by the varying atmospheric conditions prevailing on the one hand in the tropics, over the ocean, during the summer of the temperate zone, and on the other hand in the polar regions, over the continent, and during the winter of the temperate zone. Although the observations are based only on a small portion of the earth's surface, and many of the deductions are therefore merely surmises, they seem to point to one certain fact: That the maximum of the 11-year temperature period by no means coincides over the whole earth with the minimum of solar activity. E. F.

429. *The Prött Theorem.* **F. Linke.** (Meteorolog. Zeits. 39. pp. 267–272, Sept., 1922.)—By his study of psychometric tables and graphic representations of the connection between temperature and humidity of the air, C. H. Prött was led to the discovery of laws which on account of their easy applicability merit the attention of meteorologists. He maintains that in many cases of technique and hygiene the temperature and relative humidity of the air do not sufficiently characterise the thermal state of moist air, and even lead to false conceptions. What is much more important is to determine the total thermal content of the air, consisting on the one hand of free heat as revealed in the atmospheric temperature, and on the other hand of the heat latent in the aqueous vapour. This total thermal content is, he maintains, solely indicated by the reading of an aspiration wet-bulb thermometer. He therefore provided a wet-bulb thermometer with a corresponding scale and patented it in 1913 under the name of "Pröttmeter." Especially important is the introduction of "relative saturation," instead of the hitherto customary "relative humidity." The former refers to the maximum humidity at the temperature of the wet-bulb thermometer, the latter to that at the temperature of the dry-bulb thermometer. The former refers to the maximum amount of aqueous vapour which the air can actually absorb without change of temperature, the latter to the aqueous vapour which it contains theoretically. There can be no doubt that the former is practically the more important. A mathematical working out of the laws, which does not lend itself to abstraction, is followed by various suggestions for their technical application. E. F.

430. *The Regional Peculiarities of Thunderstorm Occurrence in North Germany.* **K. Langbeck.** (Meteorolog. Zeits. 39. pp. 257–263, Sept., 1922. Comm. from Preuss. Meteorolog. Inst., Berlin.)—An inquiry based on material collected by the Preuss. Meteorolog. Inst. from 1901 to 1910. In considering the question of the yearly and daily periods a system of comparison was adopted which attempted in the first place a general mean procentual distribution for the whole district under observation, and, secondly, to ascertain the " anomalies." The regional differences thus revealed lead to a point in connection with the origin of thunderstorms hitherto insufficiently considered, which touches the contrast between continental and oceanic climate, and finds an analogy on a small scale in the contrast between mountain and valley. The following questions were investigated : (1) A relative estimate of the different districts as regards the formation of storms ; (2) the yearly period of storm occurrence ; (3) the procentual distribution of storm direction. The influence of a climatic temperature contrast on the generation of electric phenomena which is revealed by the North German observations enables us to understand the general distribution of storm frequency on the earth. Wherever there are, owing to opposition between land and sea, mountain and valley, warm and cold air currents or ocean currents, or differences in temperature and humidity, there must be increased storm frequency. Exceptions under special climatological and aerological conditions may be explained by the absence in such cases of sufficient masses of warm, humid air. E. F.

431. *A Quantised Distribution of Matter in the Atmosphere.* **H. Köhler.** (Meteorolog. Zeits. 39. pp. 263–267, Sept., 1922.)—Analyses of chlorine in hoar frost have led to the discovery that salts are present in multiples of a given fundamental quantity. Taking the mean value as 0·003451 gr. per litre, the author finds that the chlorine content per litre can be expressed by the formula $0{\cdot}003451 \times 2 \pm n$, where n may have the values 0, 1, 2 or 3. It follows from this that the salt particles in the atmosphere are also distributed in a weight proportion of $2^{\pm n}$. These facts are of the utmost importance for our knowledge of atmospheric turbulence and for molecular physics. Planck's quantum theory has cast a doubt on the continuity of natural phenomena. The discovery here mentioned may, perhaps, tend to throw new light on matter from this point of view. This distribution may possibly be found susceptible of further generalisation. Colloid chemistry appears to be a suitable field for further tests. E. F.

432. *Causes of a Few Simple Atmospheric Electrical Disturbances.* **K. Kähler.** (Metereolog. Zeits. 39. pp. 293–298, Oct., 1922.)—Measurements have been made throwing a new light on electrical phenomena in the lower air strata accompanying simple disturbances of the atmospheric electrical field. Three cases of electrification were examined : (1) Electrification by dust clouds, (2) by rain, (3) by rainless storm clouds. The experiments appear to lead to the following conclusions : (1) That the conception of a negative electrification of dust clouds is untenable. (2) That the negative fields occurring with rain cannot be explained by the upward rebound of the rain. The separation into inert positive carriers (raindrops) and mobile carriers (fine spray) is effected in the air itself. (3) That the influence of clouds is much less than has been hitherto assumed. Storms are accompanied by strongly charged masses of air, which extend downwards to the surface of the earth. E. F.

433. *The Diurnal Course in the Occurrence of Thunderstorms and a Hypothetical Explanation of their Periodic Sequence.* **K. Langbeck.**

(Meteorolog. Zeits. 39. pp. 298–303, Oct., 1922. Comm. from the Preuss. Meteorolog. Inst., Berlin.)—Based on observations at several stations in North Germany, the author's conclusions may be summed up as follows: The exchange of air between the regions of land and sea climate and between mountain and valley exercises a perceptible influence on the diurnal periods of storm occurrence. The equalising of the temperature contrasts prevailing on stormy days causes vertical pulsations of the troposphere strata, which spread rapidly and by their first impact and subsequent repetition act as storm liberators, and may thus cause a periodic sequence of thunderstorms. E. F.

434. *Trees and Lightning.* **V. Schaffers.** (Comptes Rendus, 175. pp. 1087–1089, Nov. 27, 1922.)—Leaves of different trees were subjected to a discharge from a static machine. The principal results are tabulated. No simple relation between the potential of silent discharge and the frequency of a given tree being struck was found. **Erratum,** *ibid.* p. 1448, Dec. 26, 1922.) W. A. R.

435. *Laws of Variation, in the Troposphere, of the Characteristics of Standard Air with the Altitude.* **R. Soreau.** (Comptes Rendus, 175. pp. 1041–1042, Nov. 27, 1922.)—Calculations are applied to pilot balloon observations published by the International Commission for Scientific Aerostation and relating to altitudes up to 14,000 m. They are based on the pressures established in the course of 80 ascents effected between July 1, 1911, and July 1, 1912. A table gives the means p and the relation $\mu = p/p_0$, where p_0 is the value of p at sea-level. Taking the equation of equilibrium as $dp = -adz$, the differences Δp from kilometre to kilometre may be considered as proportional to the densities a of standard air at the altitudes $z = 500$ m., 1500 m., 2500 m., . . . From the curve (Δp, z) are deduced the relations $\lambda = a/a_0$ at altitudes of 1000 m., 2000 m., 3000 m, . . . , and the values of the functions M and L, such as $z = \mathrm{M} \log \mu$, $z = \mathrm{L} \log \lambda$. The calculations lead to the conclusion that the functions M and L are maintained over considerable spaces, such as temperate Europe, so that p_0 and a_0 are sufficient to characterise the standard air of a region. The table also gives the value of the parameter $\nu = \mu g/\lambda g_0$, which would be theoretically equal to the relation T/T_0 of the absolute temperatures if the relation between aqueous vapour tension and barometric pressure were constant and if the temperature were not affected by the phenomena following on the condensations in the troposphere. Towards 12,000 m., the mean altitude marking the limit of the troposphere, ν passes through a minimum. The curves of M, L, and ν in function of z have the shape of a flattened wave on the chord limited by the extremities of the photosphere. The following approximate formulæ were found: $\mathrm{M} = 19230 - 0{\cdot}22\,z$, $\mathrm{L} = 23000 - 0{\cdot}25\,z$, $\nu = 1 - 0{\cdot}0000205\,z$. E. F.

436. *Pyrometry of Solar Radiation.* **W. Brückmann.** (Meteorolog. Zeits. 39. pp. 107–110, April, 1922.)—The application of optical pyrometers to meteorological work is dealt with, and the pyrometer of Holborn and Kurlbaum [Abs. 1196 (1903)] briefly described, along with Henning's spectroscopic modification of it. For general meteorological purposes, the original and simpler form of the instrument is more useful, since the determination of many spectral colours is impossible owing to the rapid change of conditions. Sufficiently definite results are obtained by the use of two colour filters—red (λ, 622 μ) and green (λ, 520 μ). A few preliminary results are given. In a single day the radiation intensity at the zenith of the green ray is greater than that of the red; whereas the intensity of the red is greater towards the western horizon. On different days the zenith intensities vary with atmospheric clarity. W. A. R.

437. *Solar Radiation and Ionisation.* **A. Nodon.** (Comptes Rendus, 175. pp. 1086-1087, Nov. 27, 1922.)—Former researches on the effect of direct solar action were continued [Abs. 2079 (1907); 119 (1923)]. The discharge rate of an electroscope with negatively charged aluminium leaf was observed either when directly exposed to the sun's radiation; or to a clouded sky; or with screens of various materials, such as wood, paper, radio-active-coated materials, etc., interposed between the instrument and direct sunlight. Previous results were confirmed. Most rapid results were arrived at during periods of great solar (and magnetic) activity. The discharge is always more rapid under the action of direct sunlight than when screened. The discharge effect is increased in the presence of radio-active material, but its intensity varies with the activity of the external radiations. W. A. R.

438. *Progress in Solar Radiation Measurements.* **C. Dorno.** (Meteorolog. Zeits. 39. pp. 303–323, Oct., 1922.)—Experiments at Davos from October, 1920, to June, 1922, are recorded. The primary object of these experiments was to obtain a trustworthy continuous registration of the total intensity of the solar radiation in absolute measure of the calorie. Marvin's pyrheliograph is the only one hitherto existing for this purpose. It does not give a connected curve, but only intermittent values. The author has devised a parallactically mounted pyrheliograph which follows the sun's course and combines the principles of the Michelson actinometer and the Ångström pyrheliometer. Following on a detailed description of the construction of the instrument, the results of the observations are given in numerous tables, which cannot be readily abstracted. E. F.

439. *Chemical Composition of the Earth's Crust.* **W. Vernadsky.** (Nature, 110, p. 229, Aug. 12, 1922.)—A brief communication stating that the elements of different atomic numbers can be grouped according to the part they play in the economy of the earth's crust. For example, 86·4 % of the elements constituting the mass of the earth's crust have even atomic numbers. The elements are divided by the author into six classes. W. R. C.

440. *Electrical Earth Currents in France.* **C. Maurain and Mme. de Madinhac.** (Comptes Rendus, 175. pp. 1046–1047, Nov. 27, 1922.)—A closed contour, bounded by portions of parallels and meridians, and containing the greater part of France, was examined for the existence of vertical earth currents. A current, directed upwards, of 0·0043 ampere per sq. km. was found. Bauer's examination of the whole earth indicated that France is situated where the current changes sign, and its feeble character would be thus accounted for. W. A. R.

441. *Geographical Analysis of Ocean Temperatures at the 45th Parallel.* **F. Kerner-Marilaun.** (Akad. Wiss. Wien, Ber. 129. 2a. pp. 387–418, 1920.)—So far as the ocean temperatures outside the tropics admit of a geographical explanation, they have already been discussed and elucidated by Hann and Voeikof, Köppen and Krümmel. But it is worth while to subject thermogeographical problems to the test of figures. This necessitates a stricter definition of several assumptions and the solution of new problems. Classifying the ocean basins thermally, we might call the North Atlantic Ocean overwarmed, the South Pacific normally warm, and the North Pacific, on account of its great temperature fluctuations, continental, if the term be permissible. The following main points are considered: Analysis of the warming influences; position of the trade wind region; thermal effect of the trade wind region; analysis of the cooling influences; determining of constants. The bulk of the paper is devoted to a mathematical analysis of the various influences observed. E. F.

442. *Tidal Oscillations in Canals.* **N. Sen.** (Calcutta Math. Soc., Bull. 12. 4. pp. 271–290, March, 1922.—The paper contains mathematical analyses of tidal oscillations for several new cases of canals, all symmetrical about a vertical plane through their centre line. Various laws as to the variation of the breadth and depth are taken and examined in detail [Abs. 1698 (1905)]. W. A. R.

443. *Transversal Seismic Waves on Surface of Heterogeneous Material.* **K. Aichi.** (Phys. Math. Soc. Japan, Proc. 4. pp. 137–142, July, 1922. In English.)—Observation shows a preponderance of the transverse waves in transmission of the main shock of an earthquake; hence the necessity for an extension of the usual theory of the surface wave, introducing the heterogeneity of the material. Love (*Some Problems of Geophysics*, p. 160) has discussed the propagation of the transverse waves in a homogeneous superficial layer overlaying a homogeneous material differing from the surface layer in rigidity and density. The author has succeeded in finding a special case of a heterogeneous material which admits of complete solution, and believes that the main features of the general case may be inferred therefrom. Taking rectangular coordinates with the positive Z-axis vertically downwards, he assumes the transverse displacement η given by the equation $\eta = Y(z) \cos (pt + fz)$, where period $T = 2\pi/p$, wave-length $\lambda = 2\pi/f$, and propagation velocity $v = p/f$. Assume the density ρ and rigidity μ, functions of z only, given by $\rho = \rho(z, \mu = \mu(z)$. Then the equation of motion will be $d^2Y/dz^2 + (\rho p^2/\mu - f^2)Y = 0$, with the boundary conditions that at the surface $z = 0$ the normal stress vanishes, so that $dY/dz = 0$ for $z = 0$; and that there is no deep penetration of the waves, so that $Y = 0$ for $z = \infty$. Among the many possible expressions for ρ and μ, $\rho = \rho_0 e^{\beta z}$ and $\mu = \mu_0 e^{\alpha z}$ are selected as leading to the case admitting of complete solution. This approaches the linear law when z is small, and the large variation in ρ and μ as z varies is unimportant, since the values of ρ and μ at a depth, large compared with the wave-length, can have no large influence on the propagation of waves of that wave-length. The equation of motion is then $d^2Y/dz^2 + \left\{e^{(\beta-\alpha)z}p^2 - f\right\}Y = 0$. Putting $\xi = e^{(\beta-\alpha)z/2}$, $4\rho_0 p^2/\mu_0(\beta - \alpha)^2 = k^2$, $4f^2 = m^2(\beta - \alpha)^2$, the equation becomes $\xi^2 d^2Y/d\xi^2 + \xi dY/d\xi + (k^2\xi^2 - m^2)Y = 0$, the solution of which is $Y = CJ_m(k\xi)$

$+ C'J_{-m}(k\xi)$. Now when ρ/μ increases with z, $\beta - \alpha$ becomes negative, so that $\xi = 0$ for $z = \infty$, and $\xi = 1$ for $z = 0$. Then, since $dY/dz = 0$ for $z = 0$, the solution is $Y = CJ_m(k\xi)$; and since $Y = 0$ for $z = \infty$, $J'_m(k) = 0$. Hence $Y = \sum iC_iJ_m(k_i\xi)$, where $k_1, k_2, \ldots$ are the roots in ascending order of magnitude of $J'_m(k) = 0$. And for k_1 only does Y decrease continuously from 1 to 0 as z increases from 0 to α, the max. values of k_1 for the other roots occurring at intermediate values of z. For surface waves, therefore, $Y \doteqdot C_1J_m(k_1\xi)$. Now $\alpha - \beta$ is small, so that the Bessel function is of the high order for which J. W. Nicholson and Debye have obtained semi-convergent series of three types according as $M \lesseqgtr k$. In the present case $J'_m(k) = 0$ has a root only when $k > m$; whence

$$J_m(x) = \frac{1}{\pi}\sum_{n=0}^{n=n} A_n(\tau)\frac{\Gamma(n + 1/2)}{(x \sin \tau/2)^{n+1/2}} \cos\left\{x(\sin \tau - \tau \cos \tau) - (2n+1)\pi/4\right\}$$

where $\cos \tau = m/k$, $A_0(\tau) = 1$, $A_1(\tau) = 1/8 + 5 \cos^2 \tau/24, \ldots$; hence $J'_m(k) \doteqdot 0$, i.e. $mJ_m(k) \doteqdot kJ_{m+1}(k)$ is obtainable from

$$\sin\left\{k(\sin \tau - \tau \cos \tau) - \pi/4 = 0\right\}$$

Assuming τ small, $\tau^3 \doteqdot 3\pi/4m$; hence, putting $v_0 = (\mu_0/\rho_2)^{1/2}$, the value of v if the material were homogeneous, $v_0/v \doteqdot 1 - [3\lambda(\alpha - \beta)/16]^{2/3}/2$ (showing the dispersion) $\doteqdot 1 - h\lambda^{2/3}$, say, so that for λ small, $v = v_0(1 + h\lambda^{2/3})$, giving as the approximate group velocity $v_0(1+h\lambda^{2/3}/3)$. The decrease of displacement with the depth can be inferred from $Y = C_1J_m(k_1\xi)$, $\xi = e^{(\beta-\alpha)z/2}$, and the series expression above for J_m. It is found that $J_m(k_1) \doteqdot 0{\cdot}692m^{-\frac{1}{3}}$, while

$$J_m(m) = \Gamma(1/3)m^{-\frac{1}{3}}/6^{1/6}\pi = 0{\cdot}447\, m^{-1/3}$$

Thus the displacement decreases to 65 % when $k = m$, i.e. when $(\alpha - \beta)z/2$ has the value $(3\pi/4m)^{2/3}/2$. It can be inferred from the series convergent expression for $m > k$ that when $(\alpha - \beta)z/2$ increases further by $(3\pi/4m)^{2/3}$, the displacement almost vanishes. The case for $\beta - \alpha < 0$ can be solved by exactly similar procedure, introducing a Bessel function which vanishes when the argument is infinite. The case when the surface layer has the density and rigidity as above, while the subjacent material is homogeneous, is also soluble.

G. W. de T.

444. *Solar Prominences.* **B. G. Swindells.** (Observatory, 45. pp. 314–316, Oct., 1922.)—An analysis of 32 years of observation of prominences by J. Fényi, at the Kalocsa Observatory. The three series of data—prominence numbers, prominence magnitudes, and sunspot numbers—coincide in their maxima and minima to within a year. The chief periodic changes are: At minimum, the chief prominence activity is about lat. 50°, a deep flat trough at the equator and nothing at the poles; at maximum, the chief activity is at the poles for a short time. The changes in latitude of prominences coincide in period with the changes in activity in sunspots. The suggestion is made that the prominences constitute the origin of the coronal rays. The most important point is that the two hemispheres of the sun are not equal in activity at any one time, but the changes are of such a nature as to indicate that the activity of one hemisphere makes up for what is lacking in the other. A. S. D. M.

445. *Stellar Radiometry with Vacuum Thermo-Couples.* **E. Pettit** and **S. B. Nicholson.** (Mt. Wilson Observat. Contrib. No. 246. Astrophys. J. 56. pp. 295–317, Nov., 1922.)—The construction of vacuum thermo-couples whose elements weigh about 0·03 mg. is described and their efficiency at various pressures discussed. The optimum efficiency is only about 10^{-4} %. The deflection of the galvanometer is recorded on a moving photographic plate, the e.m.f. being repeatedly reversed so that the double throw is indicated. Records with and without a water cell are obtained for several stars. Other applications of the thermo-couples are made to the determination of solar spectral energy distribution, energy variations across sun-spots and faculæ, and monochromatic energy distributions over the solar disc. The apparatus is also embodied in a recording micro-photometer in which a vacuum thermo-couple, D'Arsonval galvanometer, and recording camera replace the usual photo-electric cell and electrometer. A. Wh.

446. *Stellar Radiometry and Spectral Energy Distribution.* **W. W. Coblentz.** (Bureau of Standards, Bull. 17. pp. 725–750 [Sci. Papers No. 438], 1922.)—The application of vacuum thermo-couples to stellar work is described and the sensitivity of various metallic combinations tabulated. The thermo-couples finally used are bismuth-tin against bismuth-antimony, the material being in the form of wire 0·025 mm. diameter. The stellar image is received on a blackened disc 0·5 mm. diameter. Two such elements are mounted in each vacuum container. The 100-cm. reflector of the Lowell Observatory is used with these instruments, and results are obtained verifying previous observations that red stars emit three or four times as much total radiation as blue stars of the same visual magnitude. The spectral energy distributions of sixteen stars are obtained, using absorbing screens of quartz, water, and red and yellow glass. These do not agree with the distributions from black bodies. From comparison with the nearest black body curves, it is deduced that the temperature varies from 3000° K for red, class M, stars to 10,000° K. or higher for blue, class B, stars. Binary stars, with companions of low luminosity, show an excess of infra-red radiation. A. Wh.

447. *Electron and Röntgen-Ray Emission from Stars.* **H. Deslandres.** (Comptes Rendus, 175. pp. 506–512, Oct. 2, 1922. **Erratum,** *ibid.* p. 1448, Dec. 26, 1922. Nature, 110. pp. 847–849, Dec. 23, 1922.)—The researches of Störmer on magnetic storms and the aurora and their relation to sun-spots prove the emission of electrons from the sun. The emission of a radiation having the characteristics of a hard Röntgen radiation is indicated by Kohlhörster, who finds the closed vessel ionisation in the atmosphere to be, at 9000 metres, eight times its value at sea-level. This radiation is either from the sun or, less probably, from cosmic space. Considering yellow stars only, the intensity of the calcium lines in the chromosphere is greater for giants than for dwarfs. As temperature and pressure are similar in the emitting layers, an ionisation difference is indicated, demonstrating the presence of a penetrating Röntgen radiation from the giant nuclei. Eddington shows that the temperature at the centre of a yellow star, one and a half times the solar mass, will be about 4,650,000°. This corresponds to a black body maximum intensity wave-length of about 6 Å.U. Thus an appreciable proportion of penetrating rays might be emitted from the larger stars. Another source of ionisation may be the disintegration of atoms, accompanied by α, β, and γ radiation. The radiations are also present in nebulæ, both gaseous and planetary. A. Wh.

448. *Planes of Spiral Nebulæ in Relation to Line of Sight.* **J. H. Reynolds.** (Roy. Astron. Soc., M.N. 82. pp. 510–513, Oct., 1922.)—A previous investigation of spiral nebulæ of at least 10′ in diameter is now extended to smaller nebulæ. There appears in all cases to be an excess of small inclinations to the line of sight compared with the theoretical figures for a random distribution. The average angles of inclination for those of 10′ and upwards is 21°·9, for those from 5′ to 10′, 24°·2, and for those from 3′ to 5′, 26°·7. So the tendency to excess of small inclinations is rather less for the smaller nebulæ. It may be inferred that there must be some relationship between the distance of the nebulæ and our position on the galaxy, thus supporting Shapley's contention that the galaxy is very much larger than the spirals, and not of the same order of size. W. W. B.

449. *Electrification of Bodies which Radiate Corpuscles.* **E. Schweidler.** (Terrest. Magn. 27. pp. 105–118, Sept., 1922.)—The author considers the effect of corpuscular radiation on the electrical state of the heavenly bodies, and the action of the charges of these bodies on the stream of corpuscles. The energy of a corpuscle (electron, proton particle, or α-particle) is $E = mc^2[(1/\sqrt{1-\beta^2}) - 1]$, where $\beta = v/c$, which is identical with $E = \frac{1}{2}mc^2\beta^2 = \frac{1}{2}mv^2$ for small values of v. E may also be considered as the product of a potential P (the radiation potential) and the charge e of the particle. A solid uncharged sphere, with radius a, sends out homogeneous corpuscular radiation, the radiation potential being P_0. The sphere gains a charge of opposite sign, and produces a retarding field, so that, in the end, as many particles are drawn back into the surface as leave it in unit time. Until the charge has reached the value P_0a the ejected particles travel to an infinite distance; when this value is exceeded the particles come to rest at a finite distance A, and are drawn back to the surface in a total time 2T for the to-and-fro journey. When the stationary state is reached the particles between a and A have a total charge $-Q'$, such that $Q_a - Q' = P_0a$; $Q' = I \times 2T$, where I is the outward current from the sphere. When A is large compared with a, $2IT = P_0a^2/(A-a)$. For a sphere the size of the moon, even fast β-rays, with $\beta_0 = 0 \cdot 999$, would fail to reach the earth's orbit if they were ejected at a rate of 200 per sq. cm. per sec., which is a weak emission. A would be smaller than this for higher rates of emission. If the surface of a sphere is ionised, and it gives out a negative radiation $-I$, the field produced by the negative discharge drives the positive ions outward; and, in the end, a stationary condition is produced. The sphere charges itself to a potential π, and the potential outside diminishes with distance from the centre, first slowly, then quickly; and, after passing a point of inflexion, again slowly to zero at ∞. For high values of r the velocities of the β-rays, which have been retarded, and of the positive ions, which have been accelerated by the field, their volume densities and their current densities are equal. The radiation potential of the electrons at infinity is $P_\infty = P_0 - \pi$; while that of the + ions is π. Applying these results to the sun it is clear that at large distances the positive particles will have greater penetration than the electrons, and be bent less by magnetic fields, on account of their greater mass. It is suggested that outbursts of electrons, which sometimes hit the earth, are deflected by the terrestrial magnetic field to northern regions; and so produce the *aurora borealis;* while the + ions produce the aurora line, which is found in the light of the night sky in middle latitudes. It may be that the electron streams are deflected by the planets, when these are in certain positions, so as to return to the sun, causing periodic variations in the solar activity. H. N. A.

450. *Retrograde Satellites.* **P. Burgatti.** (Accad. Lincei, Atti 31. i. pp. 493–495, June 18, 1922.)—Continuation of an earlier paper [Abs. 2241 (1922)]. The equation of motion for satellites with direct or retrograde motion in a circle respectively is: $2\omega v\rho^2 - v_\rho^2 \mp km = 0$, where ω is the angular velocity of rotation of the central body and k a constant determining the Coriolis force. Writing $8km\omega = v_0^3$ and solving, equations for the radius for direct or retrograde motion are obtained. Direct, $\rho = (-v^2 + \sqrt{v(v^3 - v_0^3)})/4\omega v$; retrograde, $\rho = (v^2 \pm \sqrt{v(v^3 - v_0^3)})/4\omega v$. The retrograde orbits can only exist for $v > v_0$ and for any such velocity there are two solutions, giving radii greater and less than $\rho_0 = v_0/4\omega$. For direct orbits, one velocity corresponds to a unique orbit. For v_0, as above determined, there corresponds a radius $\rho_0^1 = 0{\cdot}42v_0/4\omega$ for direct motion. Values for Jupiter and Saturn of ρ_0 and ρ_0^1 are compared with observation. All the direct orbits lie within ρ_0^1 and all the retrograde within ρ_0. Although the stability of the retrograde type outside ρ_0 is doubtful, no conclusion can be drawn from their absence, as there appears to be little room for them. See has given a limit to the radius of action of planets in such cases which is little greater than ρ_0. The range of velocities thus possible is small and the existence of such orbits is unlikely even if possible. A. Wh.

451. *Determination of Colour-Equivalent of Star, and Relation of Effective Wave-Length to Spectral Class.* **K. Lundmark** and **W. J. Luyten.** (Roy. Astron. Soc., M.N. 82. pp. 495–510, Oct., 1922.)—This is a review of the different methods employed. So long as no standard scale of effective wave-lengths has been established, and their determination is subject to large personal equations and systematic differences, which have been but meagrely investigated, they cannot be regarded as equivalent to spectral classes in individual cases. A thorough and extensive investigation as to all sources of systematic differences affecting measures of effective wave-length is highly desirable. When it becomes possible to master these difficulties, effective wave-lengths may prove valuable as substitutes for spectral classes in dealing with faint stars, and in indicating luminosities when used in connection with known spectral classes. Instead of Lindblad's $\lambda_{\text{min.}}$, a $\lambda_{\text{min.}}$ obtained through ultra-violet screens is suggested for application with reflectors. A possible relation should be found between $\lambda_{\text{min.}}$, $\lambda_{\text{eff.}}$, and intensity measures in short spectra, and for this purpose the wave-length of maximum intensity from a short exposure with a slit spectrograph of low dispersion may be used instead of $\lambda_{\text{eff.}}$ W. W. B.

452. *Interferometer Measurements of the Third Satellite of Jupiter.* **M. Maggini.** (Accad. Lincei, Atti 31. ii. pp. 88–92, Sept., 1922.)—Observations of the interference fringes are made with the plane of symmetry containing the interferometer elements at different position angles. It is found that the visibility of the fringes varies with the position angle in a roughly sinusoidal manner. The variation depends also on the position of the satellite in its orbit. While the series of values obtained in superior conjunction shows obvious variations, that in east elongation is very nearly constant. Comparison of the curve of visibility variations with the longitude of the satellite in the orbit shows a general agreement with a curve connecting total brilliancy with the same longitude. Values for the ellipticity are derived and the conclusion arrived at that the luminous intensity must be irregular over the disc. A. Wh.

453. *Anomalous Dispersion in Stellar Spectra.* **M. Maggini.** (Comptes Rendus, 175, pp. 746–748, Oct. 30, 1922.)—Pressure, Doppler-effect, anomalous dispersion, and difference in gravitational potential are adduced to account for displacement of lines in a stellar spectrum. The first two causes cannot hold good for displacement of isolated lines; anomalous dispersion alone can give a plausible explanation as, for instance, in novæ and in certain cases of B-type stars. The author thinks that the values of these displacements may find a resemblance in the intensity of the anomalous dispersion near calcium rays or other substances of light atomic weight, such as we find in stellar photospheres (calcium clouds, etc.). He has studied the triplets of the secondary series of Mg, Ca, Zn, Cd, and finds that anomalous dispersion diminishes with the refrangibility of the line, and that for the three constants, a_1, a_2, a_3, characteristic of the lines of the triplet, $a_1/a_2 = a_2/a_3 = k$, and k increases in proportion with the atomic weight. A. S. D. M.

454. *Predicted Maxima and Minima of Variable Stars in* 1922. **L. Campbell.** (Harvard Coll. Obs., Circ. 227 [4 pp.], 1921.)—The author gives 548 predicted dates of maximum and minimum of 360 long-period variable stars for 1922. A. S. D. M.

455. *Some Peculiarities of Novæ.* **E. E. Barnard.** (Am. Phil. Soc., Proc. 61. 2. pp. 99–106, 1922.)—Known novæ, with one exception (Nova Coronæ, 1866), appear in the Milky Way, unheralded, remain at their greatest brightness for a very brief period, fade rapidly and then more slowly, fluctuate, and in a few years' time return to about their original magnitude. Of some of the more recent novæ, it is known that they were variable in their previous state, and they become variable again (except Nova Lacertæ, 1910) so that perhaps the great outburst is only an interruption in the usual variability; but it has not yet been possible to connect the variations before the outburst with those of the post-nova state, which is irregular in its fluctuations and in the extent of its light changes. Nova Aurigæ stands out in having a rather large secondary maximum in the summer of 1892. In their decline, novæ sometimes present a well-defined planetary disc, but finally become stellar again. Always at one period of their decline, they present a beautiful, sharply defined, crimson image, due to the α hydrogen line, outside the normal focus. Nova Persei (1901) also showed a receding spiral nebula, and the author criticises the "light reflection theory" held by some astronomers to account for this, bringing forward the new and slowly moving nebulosity photographed by Lampland in 1916 and the present nebulous disc photographed about the nova at Mt. Wilson, as arguments conflicting with the theory. The most satisfactory theory to account for novæ (especially for Nova Persei), is that the forces of equilibrium of the interior of the star are disturbed and that there is an outburst in the nature of an explosion, which, though it produces great brilliancy, does not destroy the star nor very seriously affect its variability. A. S. D. M.

456. *Distances of* 87 *Bright Stars.* **H. Shapley and M. B. Shapley.** (Harvard Coll. Obs., Circ. 232 [4 pp.], 1922.)—Continuation of Harvard Coll. Obs. Circ. 228 [see Abs. 1556 (1922)], and is also a comparison of the absolute magnitudes derived at Harvard from objective prism spectra with those obtained at Mt. Wilson from slit spectroscopes. The Harvard Absolute magnitudes are based directly on the Mt. Wilson system (Mt. Wilson Contrib., 199, 1920), but new curves have been deduced for the relation of luminosity to ratio of line intensities; the absolute magnitudes are not of high weight for dwarf stars, because these curves are not yet well established for the fainter magnitudes. The visual and absolute magnitudes and spectrum may be given as examples for the following stars: τ Ceti, 3·6; 6·1; 0″·316; G8., o^2 Eridani, 4·5; 6·9; 0″·302; K0., α Urs. Maj., 2·0; 0·3; 0″·046; G9., α Bootis, 0·2; 1·8; 0″·209; K2. A. S. D. M.

457. *New Variables or Peculiar Spectra.* **A. J. Cannon.** (Harvard Coll. Obs., Circ. 231 [3 pp.], 1922.)—The author defines the term H.V. which indicates the current number in the series of variable stars discovered at Harvard or its annexes. The first H.V. was found by G. P. Bond in 1863, the total number in 1922 being 3610. In 1901 Bailey found 593 in globular clusters, and in 1904 and 1906, Miss Leavitt found over 2000 variables in the Orion nebula, the Milky Way clouds, and the Magellanic clouds; she has found more than half of the known variables. Of the 8 new variables here announced, two seem to be of the Algol type, and two to resemble R Andromedæ. A. S. D. M.

458. *N.G.C.* 3201. **S. I. Bailey.** (Harvard Coll. Obs., Circ. 234 [3 pp.], 1922.)—An examination of this cluster was made by Miss Woods from photographs taken with the Boyden 13-inch telescope, and the results were published in H.C. 216. Further results from forty photographs with the Bruce 24-inch are in two directions. In H.C. 216, the statement was made that it is so open a cluster that practically all the stars are well separated even at the centre. This should be modified, for exposures of two and of four hours with the Bruce 24-inch reveal a background of many hundreds of very faint stars, somewhat condensed near the centre. None of these were indicated by the Boyden. There seems to be a relative paucity of stars of intermediate magnitudes. Secondly these faint stars, so far, show no indication of variability, though of the brighter stars more than one in nine is variable. Fifty-one variable stars were found, among 527 stars, within a radius of 8′ from the centre. By taking the mean of counts of stars at distances over 30′ from the centre of the cluster, the number of cluster stars within 16′ diameter was 432. The existence of these variables help in obtaining the extreme diameter of such a cluster. The N.G.C. gives the diameter of 3201 as 8′; a count of the stars would give 20′ or 25′. Miss Woods has found two variables at 19′ from the centre and others only less remote, but none further; this would indicate an extreme diameter of 38′ for 3201. These variables are almost certainly members of the cluster in spite of their great distance, unless it is assumed that some process of disintegration can cause Cepheids to wander away and become lost to the cluster while retaining their Cepheid character. A. S. D. M.

459. *Orbit of Spectroscopic Binary ζ Centauri.* **A. C. Maury.** (Harvard Coll. Obs., Circ. 233 [4 pp.], 1922.)—This binary is of the same class as μ^1 Scorpii, V Puppis, and Y Cygni, all remarkable for high velocity and great mass. An effect of approach and recession upon the spectra is given similar to, but less in degree than, that seen in μ^1 Scorpii and V Puppis. The mean width of helium lines 4388 and 4472 and of Hγ is smaller than in μ^1 Scorpii which has a shorter period, and this may be due to difference in axial rotation. Both estimates and micrometer measures are made, and the elements of the relative orbits are $P = 8{\cdot}024$ days; $T =$ J.D.2413719·321; $\omega = 290°$; $e = 0{\cdot}5$; $K + K_1 = 312$ km.; $(a + a_1) \sin i = 29{,}800{,}000$ km.; $(m + m_1) \sin^3 i = 16{\cdot}4$ times the sun's mass. A. S. D. M.

460. *H.V. 3622. A New Eclipsing Binary.* **I. E. Woods and M. B. Shapley.** (Harvard Coll. Obs., Circ. 238 [4 pp.], 1922.)—From measures made on 90 plates two solutions of the orbit have been made on the assumptions of stellar discs uniformly bright, and of discs completely darkened at the edge. No measurable secondary minimum is found. Period, 8·01964 days; eclipse is total. Photographic light of the brighter star is 0·927 and of the fainter 0·073. The observations indicate, for uniformly luminous discs, a large faint star of radius 4·2 that of sun, and of density 0·01, revolving round a small bright star of radius 1·7 that of sun, and density 0·22, with a distance between their centres of 21·2 times the solar radius. The photographic absolute mag. of brighter star is + 1·3, of fainter + 4·0. The ratio of the surface brightness is 80 and the hypothetical parallax is 0″·002. These figures are modified but not fundamentally, if darkening of the stellar discs is assumed. A. S. D. M.

461. *Distribution of Velocities of Stars of Spectral Types F to M*[1]. **G. Strömberg.** (Mt. Wilson Observat. Contrib. No. 245. Astrophys. J. 56. pp. 265–294, Nov., 1922.)—The three components of the velocities of about 1300 stars are referred to the galactic system of coordinates, assuming solar motion of 20 km. towards apex $\alpha = 270°$, $\delta = + 30°$. From Table I, it is seen that giant stars show a steady increase from + 27° to + 44° with advancing spectral type from A6 to M, and that dwarf stars apparently show a higher velocity for the sun than giants. This increase in the sun's velocity is especially marked if the stars are grouped according to space-velocity (Table II) indicating that the stars of high velocity have a systematic motion opposite to the sun's way. [See Abs. 463 (1923).] But the solar motion is only one characteristic of the general distribution of velocities. The frequency-distribution of the velocity-vectors in each of six groups (including types A6–M, and absolute magnitudes between 0 and 6) is represented by a 3-dimensional cosine-series with a large number of terms determined by harmonic analysis. From these results, curves of equal frequency are drawn in the *xy*- and *xz*-planes, and it becomes apparent that the giant stars of all types form a single "group," approximately ellipsoidal, the longer axes in the galactic plane, nearly coincident with *x* and *y*, and the shorter axis perpendicular to it. The elongation of the ellipsoid is greatest for the bright F stars, and nearly spherical for the later K and M stars. The spread of the velocity-cluster increases with advancing spectral type, and is larger for dwarfs than giants. The most frequent velocity does not coincide with the origin, but for groups of giants lies in the first quadrant of the *xy*-plane. But whatever the spectral type or the absolute magnitude, if the velocity of a star is great, there is an avoidance of the first quadrant of the *xy*-plane—no star of speed higher than 100 km. is moving in this direction. Excluding the very brightest F stars and taking from spectral types A6 to F9, abs. mag. 0 to 5·5, they divide into two streams, one coinciding with the general giant group, the other parallel to the Taurus group. This latter stream comprises about 20 per cent. of the ordinary F-type stars, and seems to show that such stars in all regions of the sky are travelling with a velocity nearly identical with the Taurus group. Even among stars of somewhat later types there are stars belonging to this general Taurus stream. The dwarf stars, among which have been included stars of spectral type GO to M of absolute magnitude fainter than 3·0, form a group of their own as regards motions; they are ellipsoidal with major axis at about 160° to *x*-axis. The most frequent velocity nearly coincides with Kapteyn's first drift. A. S. D. M.

462. *Variations in Light and Colour of Y Sagittarii.* **H. Shapley and A. D. Walker.** (Harvard Coll. Obs., Circ. 236 [4 pp.], 1922.)—Duncan found, from spectroscopic work at Lick in 1908 and Mt. Wilson in 1921, changes in the velocity curve of Y Sagittarii, *181518.* (Pop. Ast. Feb. 1922.) The velocity of the centre of mass changes from + 3·6 ± 1·2 km. to − 5·9 ± 1·5 km., and may be attributed to an unknown companion; but the increase in the eccentricity from 0·21 ± 0·04 in 1908 to 0·42 ± 0·04 in 1921, has no obvious explanation. Photographs to the number of 366 from the Harvard collection from 1901 to 1922 give light curves roughly coincident with Duncan's two spectroscopic investigations, but no permanent photometric change is found, comparable with the computed alteration in the eccentricity, though a temporary deformation of the light curve might escape detection. The mean curve is in all ways typical of the average Cepheid, and so are the ranges in magnitude, colour, and spectrum, and the agreement of colour with class of spectrum is good. A. S. D. M.

463. *Distances of Clusters.* **H. Shapley.** (Harvard Coll. Obs., Circ. 237 [11 pp.], 1922.)—From the average annual proper motion, 0″·07, of 14 faint cluster-type Cepheids, Kapteyn and van Rhijn have computed for them by the parallactic method, large parallaxes and low luminosities, drawing the conclusion (since cluster-type variables are comparable wherever found), that short-period Cepheids in clusters must be dwarfs, and the distances, assigned by Shapley to such clusters, are 8 times too great. Shapley points out: That not only the p.m.'s of cluster-type variables, but also their radial velocities are high as a rule, showing that their spatial velocity is great: That variables in globular clusters are more widely distributed in space than other stars, and therefore their intrinsic velocities are high: That stars of Class R (probably giants) and the giant variables of the M class, both have high radial velocities and are widely distributed in galactic latitude (as are cluster variables): That Y Cygni, one of the most massive stars known, moves with a velocity of 49 km. Therefore, neither high velocity nor relatively large proper motion, nor wide galactic distribution, are invariable criteria of low luminosity or of small mass. Further, Russell has shown that the procedure involving parallactic motion (used by Kapteyn and van Rhijn to get the mean distances of cluster variables) is not applicable for stars of high peculiar velocity; yet for cluster variables, the average radial velocity appears to be over 100 km. Third, the computed systematic motion of the stars used by Kapteyn and van Rhijn is not a reflection of the sun's motion, for the values of the τ-component at right angles to the sun's way, are not an approximately random distribution such as should hold for a true parallactic drift, but a distinct southern streaming. The apex of this drift is in Gal. Long. 242° Gal. Lat. + 12°, or omitting RZ Cephei (since its transverse velocity is 5 times the average for the other 13, and its p.m. has a large component, 0″·179 northward), the values are 253°, + 1°. This last position is in exact agreement with that found by Strömberg for all stars of high velocity [see Abs. 461 (1923)]. In this drift of variable stars, there may be a means of analysing the structure, direction, and speed of the general stream of high-velocity stars. Both varieties of Cepheids are found in globular clusters and it is not permissible to assign the typical Cepheids there to chance projections of galactic Cepheids on the clusters. The Cepheids in the Smaller Magellanic Cloud are comparable in every way with Cepheids of like period in the Galaxy [see preceding Abstract]. Individual period-luminosity curves for ω Centauri and the Smaller Magnitude Cloud, give an absolute magnitude greater than zero for cluster variables if it be accepted that long-period Cepheids are of high luminosity. The mean absolute magnitude for 17 long-period Cepheids is − 2·6. A table is given, for 14 Cepheids, of parallaxes found by different methods, showing the agreement. A. S. D. M.

464. *Distribution of Stars of Spectral Class.* **H. Shapley and A. J. Cannon.** (Harvard Coll. Obs., Circ. 239 [6 pp.], 1922.)—A discussion based on the Henry Draper Catalogue of the distribution of B-stars according to four classes of magnitude—all stars brighter than 5·26, and the three succeeding magnitudes to 8·25. Four diagrams are given for these orders of magnitude, Aitoff's equal area projection of the sphere being used for the system of galactic coordinates. In (1) there are 346 stars, of which 13 are in higher galactic latitude than 50°, and the rest largely conform to the "local system." The B-stars favour the southern galactic latitudes and are conspicuously non-uniform in galactic longitudes. In (2), of 367 stars, 7 are higher than 50°, and the preference for the local system is less pronounced; there is evidence of obscuration in Ophiuchus and Scorpio. In (3), about two-thirds of the 564 stars belong to the local system, and 4 are higher than 50°; the stars still favour the south galactic hemisphere, but congregate closely to the galactic equator and in galactic longitude 240°. In (4), there are 719 stars of which 4 are higher than 50°; there is pronounced crowding round the galactic equator, 90 per cent. being within 10° of it, but the average median galactic latitude is $-1^\circ\cdot 4$, which may be taken as the dip of the galactic circle for stars at the distance here concerned. This distance is computed to be 15 parsecs. The distance of the dark nebulosities in the Scorpio-Ophiuchus region may be estimated as between 200 and 300 parsecs. A. S. D. M.

465. *Relation of Spectral Type to Magnitude.* **H. Shapley and A. J. Cannon.** (Harvard Coll. Obs., Circ. 226 [4 pp.], 1921.)—About 99 per cent. of the 225,000 stars in the Henry Draper Catalogue belong to the spectral classes B, A, F, G, K, M. The authors arrange their material for statistical purposes in three tables. In Table I, the numbers of stars in each spectral class are given for successive intervals of visible magnitude; first naked eye stars (brighter than 6·25), then for intervals of a half magnitude to 9·25, then the remaining fainter stars. Of naked eye stars about 60 per cent. are earlier than the sun in spectrum, but class KO contains nearly twice as many stars as any other single class. Table II is grouped into spectral divisions, B (B0–B5), A (B8–A3), F (A5–F2), G (F5–G0), K (G5–K2), M (K5–M*c*). If stellar density for any spectral type were uniform throughout space, the numbers in Table II should double with every decrease of half magnitude in brightness; this holds partly for division G down to 8·25, but fails for the other divisions. All fail below 8·25 because of the incompleteness of the catalogue for faint stars. Table III gives the proportions in which the spectral types are mixed when analysed on the basis of apparent brightness, the G stars showing a striking increase in relative number. A. S. D. M.

466. *Spectral Class and Magnitude in Harvard Standard Regions.* **H. S. Leavitt.** (Harvard Coll. Obs., Circ. 230 [4 pp.], 1921.)—Test of whether the stars on the whole grow redder with increasing faintness, drawn from the material in Harvard Annal 71, No. 4, where, in 48 Harvard Standard Regions, the spectrum, as classified by Miss Cannon, is given for about 800 stars together with photographic magnitudes between 6·5 and 11·5. This limit is fully two magnitudes below that of the Henry Draper Catalogue, where 225,000 stars are investigated to magnitude 8·25 [see preceding Abstract]. Increase of redness with faintness may be due to the later stars G, K, M increasing in number more rapidly than earlier and whiter stars, B, A, F, in which case there would be no progressive change for a given class of spectrum, but the mean colour index for all classes would increase; or to some such cause as a scattering medium in space, in which case the colour indexes of stars of the same spectral class would change progressively with magnitude; or to both simultaneously. The author investigates the first hypothesis only, and by means of dividing all the stars concerned into five groups about the mean magnitude 7, 8, 9, 10, and 11, and into four sections, North, South, Partly in, and Mainly in the Milky Way; in each section the mean value of the colour index is computed for each magnitude as based on the number of stars in the different classes, and the corresponding class of spectrum is found by interpolation from Harvard Annal, 80, 151, Table IV. There becomes evident a progressive change in the average class of spectrum, making the stars included in H.A. 71, taken all together, appear redder with increasing faintness from the 7th to the 10th or 11th magnitude. A. S. D. M.

467. *Calculation of the Magnetic Moment of a Star, Starting from its Moment of Axial Inertia, its Period of Sidereal Rotation, and from the Universal Constant of Gravitation.* **L. Décombe.** (Comptes Rendus, 175. pp. 872–875, Nov. 13, 1922.)—In the author's theory of gravitation the force of gravity is identified with a residual electrodynamic action existing, at great distances, between any two atoms. If, as is possible, the electrodynamic phenomenon is itself the result of a modification of the electrostatic action set up by the motion of the electrified particles, gravitation may be considered due to residual electrostatic action. Supposing the earth to be homogeneous we find that the magnetic field at its surface is identical with that which would be due to an infinitely small magnet aligned with the poles and has a magnetic moment expressed in electromagnetic units by the formula $M = \frac{1}{3}I\frac{\omega}{c}\sqrt{\phi}\frac{1}{K}$, where I represents the moment of inertia of the planet in relation to the line of the poles, ω its angular velocity of sidereal rotation, ϕ Newton's universal constant, K the specific inductive force of the planet, and c the velocity of light. The author claims for this formula that it establishes a general relation between solar or planetary magnetism and the constant of gravitation. A table gives the value of the magnetic moment of planets whose period of revolution is known, calculated by this formula on the hypothesis that $K = 1$, the magnetic moment of the earth being taken as unity. E. F.

468. *Statistics of Faint Stars in a Limited Region of the Milky Way.* **L. Picart.** (Comptes Rendus, 175. pp. 865–867, Nov. 13, 1922.)—Granted that the minimum exposure t for obtaining the trace of a star on a photographic plate varies with the apparent brightness of the star, it is evident that between t and the magnitude m of the star there is the relation (1) $\log_{10} t = 0{\cdot}4m + K$, K being a constant depending on the sensitiveness of the plate, the state of the sky, etc. Operating under the same conditions with plates of the same emulsion, the formula shows that when t is multiplied by λ the magnitude of the stars at the limit of visibility is increased by $\log \lambda/0{\cdot}4$. For a given region let n be the number of stars of magnitude equal to or less than m. Given equal brightness and uniform distribution we should have (2) $n/n_0 = (2{\cdot}512)^{\frac{3}{2}(m-m_0)}$, n_0 being the number of stars of magnitude equal to m_0. Eliminating m between (1) and (2) we get (3) $\log t = \frac{2}{3}\log n + K_1$, K_1 being a new constant. If the hypotheses be correct, a series of exposures varying in length in geometrical progression should give a number of stars also varying in geometrical progression, the ratio of the latter being that of the former raised to the power $\frac{3}{2}$. Equal brightness is inadmissible, but formula (2) still holds good when the distribution is such that the number of stars of equal luminosity is proportional to the volume which contains them. When their number is very large we may assume an absolute mean brightness from which the actual luminosity varies equally in each direction. For this reason a region was chosen where the stars are very numerous, that of the Carte du Ciel No. 149 of the zone assigned to the Bordeaux Observatory (19h. 44m. + 16°), the negative of which contained 10,150 stars. The table of results shows that in this region there is condensation towards the 13th–14th magnitude, rarefaction towards the 15th followed by relative condensation, and well-defined rarefaction towards the 17th magnitude. This bears out the hypothesis that the Milky Way represents, in its entirety, a spiral nebula. E. F.

469. *Hypothetical Parallaxes and W. Struve.* **J. Jackson.** (Observatory, 45. pp. 341–352, Nov., 1922.)—The first successful determinations of parallax in 1838 were the natural climax to an accurate and well-nigh perfect reasoning by which astronomers by various arguments pointed to what were really the nearest stars. Bradley proved in 1727 that the parallax of γ Draconis could not exceed 1″, and this held good for the stars in general. Herschel assumed that stars were about the same brightness as the sun, and so computed parallaxes, and even the distances of clusters in terms of the average 1st magnitude stars. In 1812, attempts were made on the 6th magnitude star, 61 Cygni, because its p.m. was over 5″ annually. But between 1818–1821, W. Struve, by meridian observations, showed that the average parallax of brighter stars within 45° of the north pole, did not exceed 0″·1, and in his introduction in 1837 to his *Mensuræ Micrometricæ*, he gives the various means by which the distance of a star can be judged: (1) by comparison of the brightness of a star (example Arcturus) and the sun; (2) by their p.m.'s (example 61 Cygni); (3) by double stars (example 70 Ophiuchi). The nearest brilliant stars are those that have the greatest proper notions; stars with large proper motions are nearest where they are more brilliant, or are double with rapid orbital motion. In this chapter, Struve laid down the foundation of "hypothetical parallaxes," though Mædler in *Der Fixsternhimmel* (in 1858) first called them by this name and applied Struve's conception. A. S. D. M.

470. *Fifty-One Variable Stars.* **S. I. Bailey.** (Harvard Coll. Obs., Circ. 225 [3 pp.], 1921.)—These were mostly discovered in a systematic comparison of Milky Way photographs taken with the 1-in. Cooke. Twenty-two variables lie between 18h. and 6h. R.A., and 29 between 6h. and 18h. For the 51 stars the mean brightness for maximum and minimum are 10·0 and 11·9 respectively, and the greatest variation from 8·4 at max. to less than 13·2 at min. (for No. *072005*). Attention is drawn to the two stars, 044930 b and *065911*; the first is an irregular of spectral class A0, probably of the Algol type; the second of spectral class Bp, resembling R Coronæ Borealis. A. S. D. M.

471. *Observed Maxima and Minima of Variables for 1921.* **L. Campbell.** (Harvard Coll. Obs., Circ. 235 [8 pp.], 1922.)—With the numerous observations received from many quarters, it has been possible to derive mean light curves for a majority of long-period variables. With the aid of these curves, the actual dates of maximum and minimum can be determined systematically from the new observations as received, and it is proposed in future to publish annually the observed dates in order that more prompt information may be available. The table in this circular does so for 270 variables in 1921. The designation, number and name of each variable appear in the 1st and 2nd columns, the name of the constellation being abbreviated as in the table in H.B. 771. Then follow the observed magnitude and date of maximum, and similar data for the observed minimum. The system of weights is an arbitrary one. A. S. D. M.

LIGHT.

472. *Influence of Pressure on the Refractive Indices of Some Organic Liquids.* **F. Himstedt and I. Wertheimer.** (Ann. d. Physik, 67. 5–8. pp. 395–406, June 29, 1922.)—This investigation has been occasioned by experiments concerning electrical double refraction, wherein the influence of pressure on the refractive index was required. Since the experiments of Quincke, as also of Röntgen and Zehnder, did not include the liquids used, and also showed the inaccuracy attendant upon the use of the formulæ of Beer and Lorentz, direct determinations were necessitated. The experimental arrangements used were essentially those of Röntgen and Zehnder, except that the much more convenient interferometer of Loewe-Zeiss was employed instead of Jamin's interference refractor. These arrangements are described in detail, as also the mode of experiment, and tables of data are included for brombenzol, chlorbenzol, nitro-benzol, pinene, chloroform, dichlorethylene, and hexane. The results for CS_2 agree within experimental error with those of Röntgen and Zehnder, so that those for the liquids employed will be of the same order of accuracy. The dispersion is seen to increase with increasing pressure, dn/dp growing from red to violet. When the substances are arranged in series according to increasing Kerr constants, exactly the reversed series is obtained as when the arrangement is according to increasing dn/dp, *e.g.* nitrobenzol has the greatest Kerr constant and the smallest dn/dp, and vice versa for hexane. The paper concludes with a discussion of the formulæ of Newton, Beer and H. A. Lorentz. H. H. Ho.

473. *Ultra-Violet Absorption of Toluene and Xylene.* **F. W. Klingstedt.** (Comptes Rendus, 175. pp. 1065–1067, Nov. 27, 1922.)—Applying the method of V. Henri [Abs. 1596 (1922)], the author finds that, in hexane solution, toluene has 16 bands between 2685 and 2424 Å.U., displaced with respect to the 8 bands of benzene towards the red by about 70 Å.U. The 16 bands are arranged in four groups, in each of which the intensity of the bands decreases with the wave-length, the constant mean frequency difference Δ/λ being 943 against 921·4 in the case of benzene. The three xylenes differ in their absorption; the orthoxylene has 3 wide bands; the meta has 5, both of the intensity of the toluene bands but displaced towards the red by 25 and 40 Å.U. respectively. The para has 12 bands, displaced by 50 Å.U. with respect to toluene, in 3 groups; the frequency difference Δ/λ is constant about 1186; the absorption coefficient is 4 times as large as in the other cases. Tables and curves are given. H. B.

474. *Achromatism with One Glass.* **T. Smith and L. M. Gillman.** (Optical Soc., Trans. 23. pp. 328–333, 1921–1922.)—Systems composed of thin lenses of the same kind of glass and achromatised by selecting suitable positions for the components are members of the class [AD] [BC], so that if the object is real the image is virtual. Apochromatic systems constructed from normal achromatic lenses belong to the same class. The outstanding aberrations for systems constructed of a single glass but belonging to other classes are of considerable magnitude. W. R. C.

475. *Aplanatic Telescope.* **R. Boulouch.** (Comptes Rendus, 175. pp. 1047–1050, Nov. 27, 1922.)—A discussion, mainly mathematical, of the problem of producing an aplanatic image by a system of two mirrors. The author shows that, theoretically, it is possible to obtain an infinity of solutions for the condition that coma and astigmatism shall be absent. The author points out that the practical solution of the problem requires a further investigation of the conditions. J. W. T. W.

476. *Measurement of Effective Power of Ophthalmic Lenses.* **C. Sheard** and **E. D. Tillyer.** (Optical Soc. America, J. and Rev. Sci. Inst. 6. pp. 1030–1039, Dec., 1922.)—Describes the difficulty which has arisen in the specification of ophthalmic lenses by reference to thin biconcave lenses. In the case of toric lenses and of a meniscus, the thickness and shape have to be taken into account. The measurement of such lenses by neutralisation, i.e. by finding the thin biconcave lens which will just neutralise them, is shown to be liable to error, and an instrument, termed a "lensometer," has been devised for measuring the effective power or "vertex diopters" of a lens. This instrument is described in detail with a diagram and photographs. Its range is + 20 to − 20 diopters with a cylindrical power up to 8 diopters. J. W. T. W.

477. *The Photographic Lens from the Historical Point of View.* **R. S. Clay.** (Phot. J. 62. pp. 459–476, Nov., 1922. Traill Taylor Memorial Lecture.)

478. *Classification of Optical Instruments.* **T. Smith.** (Optical Soc., Trans. 23. pp. 323–328, 1921–1922.)—Exception is taken to the classification of optical instruments by the signs of their powers, and an alternative division of five classes is proposed, based upon the separation of the four Gaussian constants into two groups according to their signs. This classification cannot be modified by the addition to the system of inverting prisms and the like, and the properties usually associated with the sign of the lens in reality depend upon its class according to the new system. Each class may have systems of positive or of negative power. W. R. C.

479. *Mechanical Construction of the Microscope from a Historical Standpoint, with Special Reference to Certain Instruments now in the Science Museum, South Kensington.* **A. Pollard.** (Optical Soc., Trans. 23. pp. 334–349, 1921–1922.) W. R. C.

480. *Polarisation and Intensity of Light Diffused by Transparent Liquids.* **J. Cabannes.** (Comptes Rendus, 175. pp. 875–877, Nov. 13, 1922.)—In 1910, Einstein attempted to establish a theory of the diffusion of light by liquids without the individual intervention of molecules. The following are his two fundamental results: (1) The light diffused at 90° to the primary bundle is totally polarised; (2) the number measuring the luminous intensity diffused laterally by 1 $cm.^3$ of the liquid is expressed, when the illumination of a normal plane of the primary bundle equals unity, by $I = \pi^2/9^{\lambda^4}(\mu^2 - 1)^2(\mu^2 + 2)^2\bar{\phi}^2$, in which λ represents the wavelength *in vacuo*, reckoned in centimetres, μ the index of refraction of the liquid, $\bar{\phi}^2$ the mean square of the fluctuation of density per unit of volume. These conclusions are not confirmed by experiment. (1) The polarisation is only partial. (2) The laboratory measurement of the diffused intensity gives a result exceeding the theoretical value of I, the divergence being the greater, the less complete the polarisation of the secondary bundle. When the liquid is sufficiently dense to admit of mutual action of the molecules, the light diffused laterally is never totally polarised, even in the case of isotropic molecules. The author multiplies Einstein's formula by a factor which gives values more closely agreeing with experimental results. The source of error in Einstein's theory lies on his assimilating liquids to continuous media of which the properties (density and dielectric constant) are supposed to vary slowly from one point to another. The depolarisation of light diffused by liquids is thus a further proof of the discontinuity of matter. E. F.

481. *Technical Applications of Interference.* **H. Schulz.** (Zeits. techn. Physik, 3. 9. pp. 284–290, and 3. 10. pp. 313–320, 1922.)—Gives an account of the applications made, in various branches of technics, of the principles of optical interference. These include the preparation of optical flats and proof planes, the examination of gauges, Twyman's method of figuring prisms and lenses, and other optical problems. In each case a concise but adequate explanation of the method is given, and in several cases the apparatus is described and illustrated. J. W. T. W.

482. *Use of Coloured Glasses in Preference to Solutions in Colorimetric Researches.* **K. Sondén.** (Arkiv. f. Kem. Min. and Geol., Stockholm, 8. No. 7. pp. 1–10, 1921–1922.)—Coloured solutions have manifest drawbacks, especially when variations in depth of tint or mixed colours are needed. Some coloured solutions, when mixed, undergo chemical reaction. Permanent coloured glasses of a few standard colours are obtainable. Tinted gelatines will furnish supplementary tints. A photographic plate is fixed, washed, and immersed in a suitable medium, such as solutions of picric acid (yellow), ferric ammonium sulphate (blue); aniline dyes have also been used, but here permanency is more doubtful. The plate is subdivided, and the portions in series furnish a gradation of tints. Allowance must be made for a slight green tint arising from the colour of the glass. Glasses so prepared may be used in a simple form of colorimeter, which the author briefly describes, and instances of their application in chemical estimations based on depth of colour are mentioned. J. S. D.

483. *Theoretical Considerations on the Diffusion of Light by Transparent Liquids. Polarisation of the Laterally Diffused Light.* **J. Cabannes.** (J. de Physique et le Radium, 3. pp. 429–442, Dec., 1922.)—The author has attempted to construct a theory of the diffusion of light by liquids which shall explain the experimental results hitherto obtained. The polarisation and the intensity of the laterally diffused light must be successively studied. The present memoir is concerned with the polarisation as being experimentally the easier and theoretically the simpler. The treatment of the subject is entirely mathematical and leads to the conclusion that in order to ascertain the anisotropy of the molecules one must not rely on the measurement of the degree of polarisation of the light diffused by liquids. The study of gases and vapours leads to more definite results, hence liquids and their vapours have been subjected to simultaneous laboratory investigation. E. F.

484. *Systems of Definitions in Photometry.* **J. W. T. Walsh.** (Phil. Mag. 44. pp. 1165–1168, Dec., 1922.)—A reply to a previous article by N. R. Campbell and B. P. Dudding [see Abs. 43 (1923)] in which it is contended that the fundamental photometric magnitude is brightness, while the concrete photometric unit is one of luminous intensity (candle-power) or of luminous flux. Of the two possible systems of definitions based on these respective magnitudes, it is suggested that the basis of candle-power is preferable, as it follows the natural order of mental conception. AUTHOR.

485. *Photometry of Luminous Sources, Consisting of Black Bodies at Different Temperatures.* **M. Vuillaume and A. Boutaric.** (Comptes Rendus, 175. pp. 688–690, Oct. 23, 1922.)—Simple variations of the methods of comparison of Crova and Macé de Lépinay as applied to luminous sources differing much in temperature are given by the authors. These give better results and such as are in much closer agreement with those arrived at by direct comparison, and they may be used for the comparison of sources which differ by more than 2000° C. Crova's method consists in effecting photometric comparisons across a trough with parallel faces containing a solution of perchloride of iron and chloride of nickel which only allows radiation near $\lambda = 582^{m\mu}$ to pass. If the brightness of the black body r expressed in W : (cm.)^2 is calculated at different temperatures, T and the emission ρ of the black body for the radiation $\lambda = 582^{m\mu}$ at the same temperatures, calculated according to the formula of Planck, the ratio r/ρ is found to vary with the temperature, contrary to the exact interpretation of Crova's method. But let a source of temperature determined and known be used as standard in the photometric measurements. Let r_0 be the brightness and ρ_0 the emission for $\lambda = 582^{m\mu}$, relative to the standard of temperature T_0, and r and ρ the corresponding values for a source of temperature T. Then there may be calculated for the temperatures T the quotients $x = \rho/\rho_0$, $y = r/r_0$, and the graph $y = f(x)$ may be constructed. This graph allows, x the ratio of the emissions for $\lambda = 582^{m\mu}$ being known, the calculation of y, the ratio of the brightnesses.

Below are given the values of x and of y relative to the comparison of sources of different temperatures T with a standard temperature T_i = 2000° abs.

T.	x.	y.	y given by the Formula (1).
2000° abs.	1	1	1
3000° „	60·9	63·8	64·8
4000° „	476	530	523
5000° „	1640	1940	1830

It appears that by supposing $y = x$, as Crova did, an error is committed which is already 5 per cent. when the temperature of the source studied has reached 3000°. The fourth column of the table contains values of y calculated by the formula

$$y = x^{1\cdot015} \qquad (1)$$

The discrepancy between the values of y thus deduced from the measurements of x and the exact values of y does not exceed $\frac{1}{80}$ at 4000° C. It is of the order of experimental errors in photometric comparisons. The formula (1) holds good for measurements referred to a standard of which the temperature is comprised between 2000° and 3000°. For standards whose temperature is outside these limits another empirical formula may be established or a graph may be used. Similarly, a new formula replacing that used by Macé de Lépinay is deduced by the authors which gives values of y agreeing excellently with those which direct comparison of the sources would give. J. J. S.

486. *Optical Analogue of the Whispering Gallery Effect.* **B. Ray.** (Calcutta Math. Soc. Bull. **12.** 4. pp. 225–230, March, 1922. Paper read before the Indian Assoc for Cultivation of Science)—The general explanation of the whispering gallery effect that the wave as a whole creeps along the surface and the wave front is perpendicular to the concave wall, has been given by Rayleigh on the principles of the wave theory [see Abs. 920 (1914)]. The analogous optical case has been studied experimentally by the author. Instead of a single belt of maximum intensity close to a moderately curved reflecting surface, a succession of maximum belts has been observed. These maxima present themselves in the form of a series of interference bands when observed at the far end of a strip of bent mirror having a light source on its surface at one end. With increase of curvature the number of bands and their sharpness increase, but their width decreases. These peculiarities are explained on the theory of geometrical optics. J. W. T. W.

487. *Measurement of Visual Acuity.* **A. Contino.** (Riv. Ottica e Meccan. **2.** pp. 40–59, Dec., 1922.)—The various scales adopted by different workers for use in conjunction with cards of Snellen type are first described. An optical method of testing which does not proceed *per saltum* has been devised by the author. This consists of (1) an illuminated disc, bearing the letter E, which is capable of being turned about its axis, and (2) two converging lenses placed between the observer and the disc. The virtual image of the disc, formed by the lenses, is viewed by the observer, who is placed with his eye 5 metres from the nearer lens. The position of the other lens is then altered until the observer is just able to determine with certainty the position of the letter on the disc. A simple formula gives the ratio of the angular size of the image actually seen under these conditions to that of a letter visible at 5 metres by an eye of acuity 1. The inverse of this ratio is marked on a scale over which moves a pointer attached to the movable lens, so that the visual acuity fraction can be at once determined as a decimal on a continuous scale. The effect of change of brightness of the image with change of magnification, and the influence of spherical and chromatic aberration of the lenses are considered in the paper. J. W. T. W.

488. *Electrical Response of the Retina to Stimulation by Light.* **E. L. Chaffee** and **W. T. Bovje.** (Optical Soc. of America, J. and Rev. Sci. Inst. **7.** pp. 1–43, Jan., 1923. Am. Illum. Eng. Soc. Trans. **17.** pp. 663–666, Nov., 1922. Abstract.)—It is well known that the optic nerve, when stimulated by light, transmits impulses accompanied by electrical disturbances which can be measured by means of a sensitive galvanometer. Previous work in this field is summarised, and some improved apparatus, involving the use of a two-stage resistance-couple thermionic amplifier, is briefly described. It was found that for very low illuminations response is proportional to the square root of the intensity of the light: for medium intensities Fechner's law holds: for very high intensities the law breaks down. This is in accordance with psychological observations. Variations in response as the eye dies have been observed: lowering of temperature produces a similar effect. Colour is also of importance. The eye of the frog is relatively insensitive to the red end of the spectrum. J. S. D.

489. *What Advances has the New Colour Theory Made?* **W. Ostwald.** (Zeits. Elektrochem. 28. pp. 398–404, Oct. 1, 1922. Paper read before Deut. Bunsen Gesell, Leipzig, Sept., 1922.)—A concise account is given of the modern, quantitative theory of colours. T. H. P.

490. *The Coefficient of Fresnel.* **C. L. R. E. Menges.** (Comptes Rendus, 175. pp. 868–869, Nov. 13, 1922.)—The author points out that his previous note [see Abs. 307 (1923)] has erroneously been described as a confirmation of the existence of a coefficient of drag, whereas the result obtained is entirely opposed. He claims to have shown that by an accurate calculation of the speed of light V in a transparent body which moves with velocity W in the direction of the luminous rays, a formula is obtained which takes count of the more recent and very accurate experiments, and this investigation shows there to be no drag—a result of great importance for theoretical work. H. H. Ho.

491. *Fresnel's Law of Ether Drag.* **C. Raveau.** (Comptes Rendus, 175. p. 947, Nov. 20, 1922.)—This note is in opposition to a paper by Menges [see Abs. 307 (1923)]. The author believes Fresnel's formula to withstand criticism and to be capable of deduction independent of the relativity of time and space [see Abs. 289 (1923)]. The present paper provides an alternative demonstration which, while less symmetrical, has the merit of greater simplicity. H. H. Ho.

492. *Sensitometry of Photographic Emulsions and a Survey of the Characteristics of Plates and Films of American Manufacture.* **R. Davis** and **F. M. Walters, Jr.** (Bureau of Standards, Bull. 18. pp. 1–120, [Sci. Papers No. 439], 1922.)—For several years the Bureau of Standards has been conducting tests and measurements of the characteristics of photographic light sensitive materials. The ultimate object of the investigation is to standardise methods and the necessary conditions for testing these materials. At the present time workers in this field are using different standards, with the result that the data obtained are not directly comparable. It is hoped that this work will lead to the standardisation that is so much needed. The paper is in three parts: Part I is a discussion of the general characteristics of photographic emulsions under the following heads: Emulsions, their preparation and classification; photographic filters; relation between exposure and density; effect of time of development on contrast; speed and inertia; scale and latitude; other methods of measuring plate speeds; effect of bromide; development. Part II describes the apparatus and conditions of testing as practised at the Bureau, *e.g.* light source; sensitometer; development of test plates; measurement of density of test plates; spectrograph; filter factor apparatus; resolution; halation; fog. Part III gives data on practically all brands of emulsions made in U.S.A. coated on glass and celluloid, the trade names of the emulsions being omitted. These experimental results are dealt with in chart form, and so this part consists of (*a*) explanation of charts, (*b*) supplementary introduction to charts, and (*c*) charts of characteristics of plates and films. A. E. G.

493. *Energy Exchanges in the Formation of the Latent Image of a Photographic Emulsion.* **S. E. Sheppard** and **E. P. Wightman.** (Eastman Kodak Co.'s Research Lab. Comm. No. 151. Optical Soc. America, J. and Rev. Sci. Inst. 6. pp. 913–916, Nov., 1922.)—A number of determinations have been made of the energy of light of different wave-lengths necessary to produce, on development, a blackening of unit density of various photographic plates; and also the energy necessary to produce the least perceptible visible blackening has been found for many commercial plates. Not so many calculations have been made, however, of the energies involved in the formation of the latent image itself. Mees, in 1915, gave certain calculations of Nutting as to the amount of energy necessary, after full development, to produce a deposit of unit density, and from this he deduced that the energy incident on a grain during exposure may be sufficient to affect only one molecule in the grain, and the latent image may be composed of grains in each of which, on the average, only one molecule has lost an electron by the action of light. A recent recalculation of Nutting's value shows that it is probably much too small. Lately Volmer made some calculations, based on the measurements of Leimbach, of the ratio of altered to unaltered molecules of silver bromide in a grain of a certain size. He used for this purpose, however, the energy of blue light ($\lambda =$ about 450 $\mu\mu$), which would produce a density of unity, and failed to take into account that only about 1/2 the total surface of the grain would be exposed. He also assumed the grain to be spherical, whereas in most emulsions, grains of the size which he used for his calculations are tabular with an average thickness from 1/2 to 1/12 the mean width. Taking Leimbach's value for the visible threshold value after development for the Schleussner plate, calculations are here given which make the ratio of altered to unaltered molecules $n : \mathrm{N} = 1 : 8{\cdot}6 \times 10^8$ and $n : \mathrm{N}_s = 1 : 2{\cdot}5 \times 10^5$, where $n =$ number of altered molecules, $\mathrm{N} = 2{\cdot}06 \times 10^9$ molecules per grain, and $\mathrm{N}_s = 6 \times 10^6$ molecules per surface exposed. This ratio is different for every different-sized grain, but for this particular grain is considered still too large. The paper concludes with a short discussion of seven possible energy changes which can occur when light falls on the grain. A. E. G.

494. *Characteristic Curve of a Photographic Emulsion.* **F. C. Toy.** (Phil. Mag. 44. pp. 352–371, Aug., 1922. Comm. No. 22 from the Brit. Phot. Research Assoc. Lab.)—A theory is advanced which explains the relation found experimentally between the number of geometrically identical silver halide grains made developable and the light intensity. It is assumed that there exist in the grains particles which are not silver halide, and which are formed during precipitation and subsequent ripening. With any normal exposure (i.e. one which gives a value between 0 and 100 for the percentage of developable grains), it is these particles which form the reduction nuclei, the only action of the light being to change their condition in such a way that they become susceptible to the action of the developer. Each nucleus does not necessarily require the same intensity to change it. The nuclei are scattered haphazard amongst the grains according to the laws of chance, and only grains which have at least one will be developable. The sensitivity of a grain is the sensitivity of its most sensitive nucleus.

The effect of a variation of grain size is explained, and it is shown that Svedberg's assumption regarding the similarity of the light-sensitive material in large and small grains is not in agreement with the experimental facts in the case of a fast emulsion. AUTHOR.

495. *Photo-Electric Effects of the Phosphorescent Sulphides of the Alkaline Earths.* **K. Göggel.** (Ann. d. Physik, 67. 4. pp. 301–319, May 23, 1922.)—The object of this paper is the establishment of the spectral distribution of photo-electric effects of known phosphorescent substances by the methods of Lenard and Saeland [see Abs. 873 (1909)]. Experimental details are given in full for the sulphides of the alkaline earths. The data obtained quantitatively support the photo-electric theory of phosphorescence. The spectral process of the effect corresponds to the superposition of normal and selective photo-electric effects. The regions of selective effect which exhibit very pronounced maxima, occur so far as expected in conjunction with the spectral *d*-source maxima of the particular phosphorescent substance. The normal photo-electric effect corresponds in its spectral distribution to the *u*-source. It follows that *d*- and *u*-sources which produce the after-luminosity, arise in the separation of electrons which can escape outwards. That these electrons emanate from the atoms of the active metals (Bi, Sr) is shown by the diminution of the effect for decreasing metallic content. A photo-electric effect corresponding to the *m*-source (fluorescence) was not found, so that for the production of fluorescence no electrons are emitted from the luminous centre, a result in agreement with the work of Pauli. The observations with simultaneous extinction of the phosphorescence permit the conclusion that escape and return of electrons can take place from the united metallic atoms in the phosphorescence centres, between entirely independent orbits. Phosphorescent substances extinguished by pressure do not exhibit a selective photo-electric effect. H. H. Ho.

496. *Phosphorescent Preparations of Boric Acid.* **R. Tomaschek.** (Ann. d. Physik, 67. 5–8. pp. 612–648, June 29, 1922.)—By the discovery of the capacity of certain organic substances when mixed with boron trioxide hydrates to produce luminous after-effects, a new class of phosphorescent materials has been made accessible for investigations into the mechanism of phosphorescence. The present paper details a study of 5 such mixtures, viz. of boric acid with phthalic anhydride, terephthalic acid, naphthalic acid anhydride, uranin (sodium fluorescence) and phenanthrene. Methods of preparation are first given, followed by a description of an investigation of the emission, which is then compared with the phenomena afforded by the alkaline earths. A section is devoted to the destruction of phosphorescence by light. The spectra of the phosphorescent mixtures were found to consist of narrow bands, and the idea of composite bands for the individuals of the spectrum is acceptable. It appears probable that the force fields of the emission centres run almost exclusively in the interiors of the organic molecules. From the study of phosphorescent inhibition by light it was proved that no causal connection arises between the luminosity and the decomposition of the organic molecule. The modes of distribution of the exciting centres of the 5 substances were examined, and the similarity of the individual bands established. As in the case of the alkaline earths, 3 processes were detected, viz. one of duration, one of ultra-violet origin, and one momentary. From a study of the absorption of light from the different mixtures, agreement was found with the conclusions arrived at for the distribution of the exciting centres. In particular with the phenanthrene mixture, the presence of a large number of narrow bands was connected with the fluorescence bands in solution. The terephthalic acid mixture exhibited very brief centres, which were not, however, of uniform duration. From the course of the I/L curve, the impossibility of a bimolecular reaction as a cause of after luminosity was established, and similarly the alkaline earth data pointed to a photo-electric process as the basis of the phenomenon.

H. H. Ho.

497. *Ultra-Violet Absorption Spectra of Pyridine and Isoquinoline.* **H. Fischer** and **P. Steiner.** (Comptes Rendus, 175. pp. 882–884, Nov. 13, 1922.)—The paper embodies in tabular form the results of measurements of the absorption spectra of pyridine and isoquinoline in solution of hexane, ether, and alcohol; and for pyridine in CCl_4 and in water. Six bands were observed in the case of pyridine and 10 in the case of isoquinoline.

A. B. W.

498. *Band Spectrum Associated with Helium.* **Y. Takahashi.** (Phys. Math. Soc. Japan, Proc. 4. pp. 187–193, Nov., 1922. In English.)—The author proposes a model molecule of helium which illustrates the double-headed bands observed by Fowler [see Abs. 557 (1915)]. The model proposed is not limited to the case of helium, but may be applied to any molecule. It is assumed that of the two electrons in the helium atom, the one revolving in the outer orbit plays the most important part in the emission of the double-headed bands.

A. B. W.

499. *Excitation of the Spectrum of Mercury. The Influence of Helium.* **G. Déjardin.** (Comptes Rendus, 175. pp. 952–955, Nov. 20, 1922.)—The arc spectrum of mercury is composed of a system of triplets, a system of isolated rays, and numerous rays of combinations and inter-combinations. The spark spectrum, which up to the present has been little studied includes a large number of rays not classed in series. The conditions of excitation of the spectrum of mercury are investigated in this paper by analysing, by means of spectrographs, the radiations emitted by the vapour of mercury traversed by electrons of different velocities. The apparatus used is a tube with three electrodes (a filament of incandescent tungsten, the grid and plate being connected to form the anode). A difference of potential increasing progressively from 0 to 100 volts is applied between filament and anode. The region comprised between the electrodes (in front of which the tube has an aperture covered with a quartz disc) is projected by means of a quartz lens upon the window of the spectroscope. The pressure of mercury vapour in the apparatus ranges between 1^{μ} and 2^{μ}. When the velocity of the electrons is slightly greater than the critical velocity of ionisation, corresponding to 10·4 volts, a large number of the rays of the arc spectrum of mercury is obtained upon the photographic plate, with an exposure of at least 30 minutes. These rays are emitted solely in the region between the grid and the plate. When the potential is increased to about 16 volts a luminosity appears in the neighbourhood of the electrodes. This luminosity also gives the arc spectrum, but the rays are now emitted between the grid and plate and also in the neighbourhood of the filament. The experiments described show that the arc rays cannot be excited separately and that the emission of the arc spectrum seems to necessitate the ionisation of the atom. The spark spectrum appears only for potential values higher than the potential of ionisation or of illumination. Certain rays become visible or at least are clearly reinforced at about 20 volts, others appear at voltages 30 to 40, while the ray 4797 only becomes visible towards 45 volts. These potentials must not, however, be considered as exactly determining the limits of excitation; these results simply show the complexity of the spectrum and the existence of several groups of rays of different character. For electrons traversing an atmosphere of helium, there exists a first critical velocity corresponding to 20·4 volts. Whatever may be the explanation, the important modification of the mercury spectrum in the presence of helium reveals the complexity of the phenomena, and shows that it differs from the ionisation of the vapour of pure mercury by electrons of sufficient velocity. Below 20·4 volts the radiation emitted by a mixture of the vapour of mercury and helium gives the arc spectrum of mercury such as is observed in the absence of helium. Starting from 20·4 volts the spectrum of mercury is modified and, at the same time, the spectrum of helium appears with increasing intensity, depending upon the pressure of the gas. A. E. G.

500. *Spectrum of the Luminosity of the Brush and the Glow Discharge of Electricity.* **U. Yoshida** and **H. Hirata.** (Kyoto Coll. Sci., Mem. 5. No. 2. pp. 143–144, Dec., 1921. In English.)—In a previous paper [Abs. 1290 (1921)] the authors discussed the appearance of the positive and negative brushes at the anode and kathode of an influence machine. In the present paper they describe experiments in which the luminosities in every part of the brush and glow which are seen at the terminals of an influence machine in air at ordinary pressure were spectroscopically examined separately. Using a direct vision spectroscope, the spectrum of the luminosity due to the discharges was photographed on panchromatic plates. The electric discharges were made to take place on smooth surfaces of iron electrodes, and the spectrum lines of the spark between these iron electrodes were used as the comparison spectrum for the determination of the wave-lengths. As the luminosity of the brush and glow discharges was very weak, exposures of from 4 to 8 hours were needed to take a photograph of moderate intensity. From the photographs thus obtained it was seen that the spectrum of the brush and glow was the same for all the various discharges and that it was a band spectrum belonging to the second group of nitrogen. The wave-lengths of the heads of the bands determined from the comparison spectrum of the iron spark were as follows: 4667, 4572, 4487, 4413, 4353, 4343, 4267, 4198—expressed in Å.U. These values are in fair agreement with those given in Kayser's Handbuch der Spectroscopie for the heads of the bands belonging to the second group of nitrogen. J. J. S.

501. *Band Spectrum in the Arc Spectrum of Silicon.* **C. Porlezza.** (Accad. Lincei, Atti. 31. ii. pp. 513–517, Dec. 5, 1922.)—A new band spectrum, observed in the arc spectrum of silicon, exhibits analogies with the flame and spark spectra, but contains bands not found in these (de Gramont and de Watteville). [See Abs. 1791 (1908).] T. H. P.

502. *Balmer Series of Hydrogen.* II. **E. Gehrcke and E. Lau.** (Ann. d. Physik, 67. 5–8. pp. 388–394, June 29, 1922. From the Reichsanstalt.)—Continuing previous work on the fine structure of the lines of the Balmer series [Abs. 544 (1922)], experiments have been made at liquid air temperatures. A Lummer-Gehrcke interference spectroscope was employed. The discharge tube was of U shape, and about 45 cm. length. One limb was of 1 cm. diameter and the upper end formed a small bulb, through which light was transmitted on to an inclined mirror, being thence reflected to the spectroscope. One electrode was sealed through a side tube leading from the narrow limb, the other being in the upper end of the wider limb. The greater portion of the discharge tube was immersed in a large flask of liquid air. Measurements were made of the wave-length differences of the components of H_α, H_β, and H_γ. The results show that $\Delta\nu$, the frequency difference of the components, is the same for the three lines and has the value $8 \cdot 8 \times 10^9$, which is appreciably less than the value $10 \cdot 95 \times 10^9$ given by Sommerfeld's theory. The separations observed for H_α, H_β, and H_γ were respectively 0·126, 0·0712, and 0·0557. It is pointed out that the value of $\Delta\nu$ observed is the same as that to be expected from Abraham's theory of fixed electrons, and it is considered that the results obtained confirm this theory. A. W.

503. *Selective Reflection of λ2536 by Mercury Vapour.* **R. W. Wood.** (Phil. Mag. 44. pp. 1105–1106, Dec., 1922.)—In previous papers the author has shown that the radiation of wave-length λ2536 is almost stopped by a layer of mercury vapour at room temperature a few millimetres in thickness. It is now demonstrated experimentally that the reflecting power of a quartz plate when backed by dense mercury vapour (density corresponding to 400° C.), was between 3·5 and 4 times as great as the normal reflecting power of quartz for the wave-length in question. A. B. W.

504. *Polarised Resonance Radiation of Mercury Vapour.* **R. W. Wood.** (Phil. Mag. 44. pp. 1107–1111, Dec., 1922.)—In earlier papers on this subject the author expressed the opinion that the resonance radiation of mercury showed no traces of polarisation, rather a surprising circumstance, in view of the fact that sodium and iodine are strongly polarised. As a result of reading a note by Lord Rayleigh in *Nature* of several years ago, the author has repeated and extended his earlier experiments. He now finds that the radiation is strongly polarised. The admixture of various gases produces marked changes in the amount of polarisation—certain gases in certain proportions completely destroying the polarisation whilst others increase it. A. B. W.

505. *Analogies of Structure between the Optical Series and the Series of Röntgen.* **L. de Broglie** and **A. Dauvillier.** (Comptes Rendus, 175. pp. 755–757, Oct. 30, 1922.)—The authors give further examples of the analogy between optical and Röntgen Series, which they have already dealt with [see Abs. 509 (1923)]. J. J. S.

506. *Scattered X-Rays in X-Ray Photography.* **R. B. Wilsey.** (Frank. Inst. J. 194. pp. 583–596, Nov., 1922.)—The secondary radiation of elements of high atomic weight consists largely of characteristic radiation, but in the case of substances of low atomic weight the characteristic radiation is negligible, and the secondary radiation is largely scattered radiation. As the elements composing the human body are of low atomic weight, the scattered type of radiation is of chief medical interest, and its effect is to diminish the contrasts and detail of a radiograph. The author describes the apparatus used to investigate secondary radiation, and this consisted of what is commonly termed a "water-phantom," above which was a small lead disc serving to absorb completely all the X-rays striking it, so that its shadow on a film could only be reached by scattered rays and the primary radiation coming from those portions of the tube outside the focal spot. The author terms the radiation which the film receives outside the shadow of the lead disc F, the focal radiation, and the radiation received in the shadow of the disc D, the diffuse radiation. The values of the total radiation T, and of D, were measured photographically, and values of the ratio D/T are given in tabular form. These values show the importance of scattered radiation, since in thicknesses corresponding to that of the human body the diffuse radiation is several times the intensity of the focal radiation, and hence the difficulty in X-raying large patients. As the most common method of reducing the scattered radiation is by means of a lead cylinder between the tube and patient, the efficiency of this method was investigated, results being shown by graphs, and whilst it produces an appreciable improvement it is not highly efficient. When scattered radiation is removed by any method there is a loss of total intensity, and the author gives a formula for the increased exposure so necessitated. Decrease of operating voltage only slightly diminishes the scattered radiation. Further tests are described of the effect of filters, and the author concludes they are not very efficient in reducing the scattered radiation, and any advantage they so have is counteracted by their selective absorption of the softer primary rays which give the greatest contrast. Further tests are described with intensifying screens, and the author concludes that such screens do not effectively diminish the proportion of scattered rays recorded upon the film.

A description of the action of the Bucky grid, as modified by Potter, is given in detail. The author decided to make a quantitative study of it to determine the effect of the various factors in its design. It was found that the efficiency depended only upon the ratio of slit width to slit depth, and was independent of the absolute size of the slit. As compared to other methods the Potter-Bucky grid is highly efficient in removing scattered radiation, and curves are given for its efficiency as a function of slit ratio. The effect of the wooden strips interposed between the lead strips in the practical form is negligible. To obtain high contrasts the ratio of slit width to slit depth must be small, and the space between film casette and patient (in which the grid is situated) should be as small as practicable. The use of a curved casette was suggested by Van Allen, and the use of lead strips in two directions was originally suggested by Bucky, but gave in practice little better definition. Other types of grid are suggested, but the difficulties of higher costs of construction for very little improvement of action render them impracticable. The author concludes that the Potter-Bucky grid is the most efficient method of avoiding scattered radiation, and the only objection is the increased time of exposure and immobilisation of the patient. B. J. L.

507. *Absorption of X-Rays in Crystals.* **T. E. Aurén.** (K. Vet.-Akad. Nobelinst, Stockholm, Meddel. 4. No. 10. pp. 1–6, 1922. In English.)—The author in a previous paper [Abs. 1443 (1921)] has shown that the molecular absorption coefficients of X-rays in chemical compounds can be calculated as the sum of the atomic absorption coefficients of the constituting elements, and the agreement of the values so calculated and the directly observed coefficients is especially good. Previous substances examined have, however, been in the amorphous state, and no experiments have been made with crystalline substances. In the case of crystals, since scattering occurs beside true absorption, one cannot assume that the total absorption can be calculated in the same manner. The present paper describes experiments to test whether the same law holds good when the substances are in crystalline form. The practical methods used are the same as in the previous paper, with the exception that in place of the absorption vessel a crystal is placed in the path of the X-rays, and the effective wave-lengths have been calculated from data given by Barkla and White. The author has examined rock salt, sylvine, calcite, gypsum, and alum, for which he gives numerical data, and concludes that the agreement of observed and calculated values is particularly good, and that the absorption in crystals can be calculated with great accuracy with the aid of the absorption coefficients found by examining amorphous substances, with the exception of cubic crystals, when the incident rays are nearly parallel to the atomic planes. B. J. L.

508. *Variation of Properties (due to Variations in Production) of Heated Metallic Oxides by Means of Interference of X-Rays.* **J. A. Hedvall.** (Arkiv f. Kem. Min. and Geol., Stockholm, 8. No. 11. pp. 1–18, 1921–1922.)—It is well known that the properties of a heated metallic oxide are very dependent upon the method of production, i.e. colour, crystal form, specific weight, and velocity of solution vary greatly with the period of heating and temperature. The best-known case is that of Fe_2O_3, but other examples are Cr_2O_3, Al_2O_3, and MgO. These variations are attributed to change of crystalline form, but there are often great practical difficulties in determining the actual crystalline form in practice, so that the author has utilised the X-ray interference method with amorphous bodies, due to Debye, which overcomes difficulties of obtaining large crystals. The theory of this method, as explained by Bragg, is given, and the equation $n\lambda = 2d \sin \phi$ derived, and then the apparatus used by Debye and Scherrer in 1915 is described and illustrated, together with the interpretation of the film produced by this method. This permits the measurement of the atomic layer distanced, and the constants of the elementary arrangement to be deduced, and hence the crystalline form. The actual apparatus used in the present experiments is then described and illustrated. The author investigated Fe_2O_3, Fe_3O_4, Al_2O_3, CoO, Co_3O_4, NiO, MgO, ZnO, CuO, and SnO_2, prepared by 27, 2, 5, 2, 3, 6, 7, 6, 11, and 3 methods respectively. The methods of preparation of each form of the above are detailed.

The author concludes that only a very few of the substances investigated are actually amorphous, and that the hydroxides of Fe, Al, Co, Ni, Cu, Mg, Zn, Ti, and Bi when dried at room temperatures are crystalline and give good interference effects. Also within the limits of experimental error, in spite of the variations in mode of production, with reference to X-ray interference, only one modification of each body was obtained.

In the case of natural and prepared oxides the space arrangement is the same. When the bodies investigated can be changed by heating to another modification having a different specific weight, colour, or solubility, no variation occurs in its crystalline form as determined by the X-ray method, so the variations cannot be explained by deformation of the structural arrangement. The author believes variations in colour to be actually due to unequal light absorption in various axes of the crystals, and he has observed such an effect with Rinman's green.

Many tables of data are given and photographs of the Debye interference films. B. J. L.

509. *The Spectral System of Röntgen Rays.* **L. de Broglie** and **A. Dauvillier.** (Comptes Rendus, 175. pp. 685–688, Oct. 23, 1922.)—In a series of notes [Abs. 1274 (1921)] the authors have pointed out that the theoretical interpretation of the experimental results of one of them, following the ideas of Smekal and Rubinowicz, permit of taking account of almost the whole of the lines observed in the series L of the elements. As the experimental data constantly justify what was foreseen, the authors consider that it is now possible to present on these bases a general system of Röntgen spectra possessing a symmetry not hitherto attained. Following the ideas of Smekal, the authors attribute to each intra-atomic electron three degrees of freedom. The whole internal structure of the atom is referred to a plane of reference called the "plane of the equator." The position of an electron in the atom is defined by its distance from the centre; the radius vector by the azimuth of its projection on the plane of the equator and by its latitude. To each degree of freedom corresponds a number of quanta:—radial quanta, equatorial quanta, and quanta of latitude. Suppose, for simplicity, the trajectory of the electron contained in a plane inclined to the equator. In the plane of its trajectory the position of the moving particle is fixed by the radius vector and the azimuth; to this last coordinate there corresponds a number of quanta (azimuthal) which is equal, as Sommerfeld has shown, to the sum of the numbers of equatorial and latitudinal quanta. Guided by the theoretical suggestions of Rubinowicz and of Bohr, the authors have taken as "principle of selection" that the number of azimuthal quanta must vary by unity on the passage of an electron from one trajectory to another. A diagram is given summing up this system, and showing it at a glance. It is based on the principle of rigorous alternation of the regular and irregular doublets (Wentzel) and the triple structure of the rays α_1 and β_2. In the diagram or table are placed in each column three figures giving respectively the numbers of quanta radial, equatorial, and latitudinal; a fourth placed below, and equal to the sum of the first and of the third, is the azimuthal quantum in question.

The lines recognised up to the present time and satisfying these principles occur in the diagram, and include eight rays recently observed by Dolejšek in the N series. The positions of lines foreseen but not yet observed are indicated, including the series O and P. Some of the rays belong to the domain of optics. The table shows for the first time the true structure of the series K, to wit, a set of lines more and more feeble and gathered close together towards the limit of absorption: α_1, β_1, γ_1..., each accompanied by a satellite of greater wave-length forming a regular doublet. The series L_3 presents an analogous aspect, with this difference that it consists of a set of regular doublets of which the components are of equal intensity. Only the line γ_8 has not yet been resolved. The series L_2 presents a remarkable anomaly, viz. the absence of the two satellites of high frequency foreseen for the lines β_1, γ_1, and γ_2. The ray β_5 of L_1 must be a triplet. The group L_1L_2 has essentially the structure of the series of Balmer, that is to say, a set of Sommerfeld doublets grouping themselves closely towards the double line of absorption. J. J. S.

510. *Series of the X-Rays.* **E. Hjalmar.** (Comptes Rendus, 175. pp. 876–880, Nov. 13, 1922.)—According to the researches of Stenström and Karcher, it appears that the M series is composed principally of three lines which Stenström designates α, β, and γ. But our present knowledge of the arrangement of atoms, at least in the case of the heavier substances, would lead us to expect many more lines. According to the combination principle, 13 different transports of electrons are possible from the N levels to the M levels, and consequently as many lines. To these must be added the lines corresponding to the transports from the levels O and P. The author has analysed the spectra of the M series in order, if possible, to discover these lines of faint intensity. The investigation was carried out at the Lund Physical Institute with the most recent spectrograph. The results are shown in two tables, of which an abstract is not practicable. In examining the α, β and γ lines, a screen of sugar and gypsum was employed. They were accompanied by an emission band in which there appeared what the author took to be a spark line. The presumption was that this emission band consisted of several lines placed close together. This supposition was confirmed by a subsequent experiment in which calcite, having a greater dispersion, was used. The γ lines of uranium and thorium and the β line of the latter substance were examined, and two or three components were found in close proximity. The existence of this multiplicity of components has been confirmed by researches on still lighter substances. E. F.

RADIO-ACTIVITY.

511. *The Mechanism of α, β, and γ-Ray Emission.* **E. Madgwick.** (Univ. of Durham, Proc., 6. 3. pp. 136–147, 1921–1922.)—The energy of an electron with velocity $v = \beta c$ (c = velocity of light) is $E = m_0c^2[(1/\sqrt{1-\beta^2}) - 1]$; and if this is converted into the energy of a γ-ray $E = h\nu$. In the case of radium B and C the wave-lengths of the γ-rays, calculated on the assumption that they are caused by the stoppage of the β-particles of these substances, do not agree with those determined by Rutherford and Andrade; but this may be due to the difficulty of measuring the wave-lengths of hard γ-rays accurately. On the other hand, if the velocities of electrons required to excite the characteristic K and L series of X-ray radiation are calculated, they are found to agree fairly well, in some cases, with those calculated from the velocities of the β-rays observed by Danysz. Rutherford has shown that, for a number of groups of β-rays, the energy differences can be represented by $pE_1 + qE_2$, where p and q are whole numbers. The author shows that a similar relationship holds for a number of lines in the γ-ray spectrum. The energy of expulsion of an α-particle, if due to mutual repulsion by the nucleus, is $E = 2Ne^2/r = \frac{1}{2}MV^2$. Geiger has recently determined the velocities of the α-particles for a number of radio-active elements, and from his results the values of r can be calculated. These values, which range from 6·4 × 10^{-12} cm. for uranium to 2·7 cm. for ThC′, are considerably larger than the accepted values for the radius of the nucleus, 10^{-12} cm.; and the author suggests a structure, in which chains of α-particles are attached to the nucleus, radiating outward from it, being held together by electrons. The relation between r and the number of electrons in the nucleus agrees quite well with this explanation of the structure; though, to explain the observed velocities of the expelled α-particles, it is necessary to assume that the nucleus, as a whole, rotates; and that the α-particle moves with a velocity compounded of this rotational velocity, and its radial velocity due to repulsion. H. N. A.

512. *Saturation Current due to Ionisation by Radium-Emanation in Equilibrium with its Disintegration Products.* **F. Broessler.** (Akad. Wiss. Wien, Ber. 129. 2a. pp. 47–57, 1920.)—In order to obtain, from a reading of the current and voltage in a condenser consisting of an earthed cylinder, with a central positively-charged rod, the amount of emanation and its products contained in it, the author has devised a method of constructing a network of curves, from which the amount can be read off directly. One set of curves consists of the current-voltage curves for different quantities of emanation. The second set are the loci of points for which the current is a given percentage of the saturation current. A more or less empirical method has been adopted in drawing the curves. It has been assumed that $i = \mathrm{I}(1 - \epsilon^{-\mathrm{E}k})$, where i and E are the actual currents and corresponding voltages, and k is a constant. I is the saturation current, which was in the first instance estimated, as it could not be observed, the corresponding value of k being calculated from measured values of i and E. Values of I which gave curves fitting the observations within 1 % were adopted. It was found that $\mathrm{I}^2k^5 = 4{\cdot}4375 \times 10^{-11}$ for $\mathrm{I} < 100$ and equals $4{\cdot}5689 \times 10^{-11}$ for $\mathrm{I} > 100$. In order to arrive at the value of the saturation current for the emanation alone, experiments were made with the disintegration products, which were left in the apparatus after the emanation was blown out. The rapid disintegration of RaA and RaC made these measurements very difficult. The author hopes, however, by a careful study of this disintegration, to be able to solve the problem. H. N. A.

513. *Constancy of the Ratio between* $\mathrm{U_X}$ *and* $\mathrm{U_Y}$ *in Specimens of Uranium of Different Origin.* **G. Kirsch.** (Akad. Wiss. Wien, Ber. 129. 2a. pp. 309–334, 1920.)—St. Meyer and V. F. Hess have shown that the ratio between uranium and actinium in ores from very different sources is constant, even when the amount of thorium differs greatly. [Abs. 1298 (1920).] The ratio of radium to uranium has been proved in various ways to be constant, and from this it follows that the ratio of $\mathrm{U_X}$ to U is constant. If $\mathrm{U_Y}$ is the connecting link between U and the actinium series, the ratio between $\mathrm{U_X}$ and $\mathrm{U_Y}$ must be constant. The rates of decay of $\mathrm{U_X}$ and $\mathrm{U_Y}$ were carefully determined. For $\mathrm{U_X}$, T = 23·82 days ± 0·075 is the time of decay to half value, and for $\mathrm{U_Y}$, T = 24·64 hours ± 0·27. Uranium ores were obtained from St. Joachimsthal in Bohemia, Morogoro in East Africa, Smalenen in Norway, and two from Ceylon. Uranium from each of these was carefully purified from all radio-active substances, including $\mathrm{U_X}$ and $\mathrm{U_Y}$; and the solution was left in each case for twenty-four hours. The $\mathrm{U_X}$ and $\mathrm{U_Y}$ which were produced in this period were precipitated with cerium nitrate, and after further treatment were placed in a small zinc dish. Measurements were made of the radio-activity, with the zinc dish uncovered, and covered with 10 μ of tinfoil, as soon as possible after the preparation, and again at least eight days afterwards. The U_Y has then all disappeared, and from these measurements the original radio-activity due to U_X can be determined. Then the first measurements can be used to find the original radio-activity due to U_Y. The measurements with the preparation uncovered, and covered with tinfoil, give the effect of the total radiation, and of the hard rays which can penetrate the tinfoil. An attempt is made with the help of these numbers to estimate the percentage amounts of U_{X_1}, U_{X_2}, and U_Y produced by the disintegration of uranium. It is estimated that more than half the total product may be U_{X_1}, while the U_Y may be less than 4·2 % of the total. This last number agrees fairly well with an estimate made by O. Hahn and L. Meitner, based on an examination of St. Joachimsthal pitchblende. In any case the experiments show that the ratio between the U_X and U_Y is the same for all the ores investigated. H. N. A.

514. *Analysis of α-Ray Photographs.* **P. M. S. Blackett.** (Roy. Soc., Proc., 102 pp. 294–318, Dec. 1, 1922.)—Theory indicates that in a collision between an α particle and an atomic nucleus the force varies inversely as the square of the distance, until the two particles approach very close; it is certain that, at sufficiently great distances from the nucleus, the effective force on the particle must follow a different law, owing to the screening of the nucleus by electrons. Particles of low velocity will not penetrate the electron screen; and, as the slowest α particles known are those at the ends of the visible tracks in Wilson's expansion apparatus, the author has made use of these in his investigation. The apparatus used to obtain photographs of the α-ray tracks was that used by Shimizu [see Abs. 208 (1922)], the reciprocating mechanism being replaced by a simple spring action for producing the sudden expansion of the moist gas. The geometrical theory of the method of measuring the photographs of the tracks, which were taken on the same plate, from two directions at right angles to one another, by using suitable mirrors, is given; and a diagram is drawn, on which each bend in a track is represented by a point with r the distance from the end of the track measured along the x axis, while ordinates represent ϕ, the angle of deflection of the particle. The theory of the collisions is developed, following Rutherford and Darwin; the probability that according to this theory an α particle with velocity v will make a collision for which ϕ lies between ϕ and $\phi + d\phi$, when travelling a distance dr, being deduced; and from this the average number of particles which are deflected through angles between ϕ_1 and ϕ_2, with remaining ranges between r_1 and r_2. In this way a theoretical distribution of the dots in the ϕ, r diagram is arrived at, which is shown to agree fairly well with that observed; and the experimental values can be used to calculate the velocities at different distances from the end of the tracks. Argon and air have both been experimented with, and velocities down to $v_0/20$ have been determined (v_0 is the velocity of emission of the α particles). Apparently the inverse square law holds between about 7×10^{-12} and 10^{-9} cm. for argon, and 3×10^{-12} and 5×10^{-10} cm. for air. No anomalous effect was discovered, either as regards frequency or type of collision. H. N. A.

515. *Note on the Curved Tracks of β-Particles.* **P. L. Kapitza.** (Cambridge Phil. Soc., Proc. 21. pp. 129–135, Nov., 1922.)—Compton has given an explanation of the curvature of the paths of β-particles in photographs taken with the Wilson expansion apparatus [Abs. 908 (1921)]. An asymmetry of the β-particle would produce this effect. There are two possibilities. The particle may have an oblate form, and not be moving along its longest axis of symmetry. It would have two electromagnetic masses; but no such difference of masses has been observed. Compton's explanation that the effect is due to a magnetic moment of the β-particle appears at first more probable. On the magnetic field due to the particle will be superposed a field due to the surrounding matter; and, owing to its electric charge, the path of the β-particle in this additional field will be a helix. In Compton's approximate calculation use is made of the value of the susceptibility obtained by ordinary experiments in a static magnetic field. The author does not consider this justifiable. Only molecules near the β-particle will be affected, and the time during which a molecule will be acted on will be very short. There will be no time for the molecules sensibly to change their orientation; and the paramagnetic effect will not be produced. On the other hand, there will be a change in the velocity of the electrons in their orbits, and this, in accordance with Langevin's theory, will produce a diamagnetic effect. The author works out a detailed theory on this basis; and finds that for appreciable curvature in the paths it is necessary that the magnetic moment of a β-particle should lie between $1 \cdot 9 \times 10^{-18}$ and $1 \cdot 9 \times 10^{-16}$. These are very large magnetic moments; and it is scarcely possible to believe that the β-particle can possess them. The magnetic field at 10^{-8} cm., i.e. at intermolecular distances, would be millions of gauss, and would affect the structure of the atoms. The "magneto electric" mass of the electron would be more than 1000 times the ordinary mass. For these reasons the author considers it extremely difficult to explain the curvature of the paths in this way. He has made similar calculations, supposing that the magnetic field of the β-particle sets the surrounding electrons in rotation; but this leads to similar difficulties. H. N. A.

516. *Radio-Active Springs, Bagnoles-de-l'Orne.* **P. Loisel.** (Comptes Rendus, 175. pp. 890–892, Nov. 13, 1922.)—The radio-activity of a number of springs in a section of about 100 sq. km. around Bagnoles was determined, and the results are presented in tabular form. A distinct relation between geological conditions and radio-activity appeared to exist. The radio-active springs are orientated in groups along a general N.W.-S.E. direction—the principal tectonic direction of the district. The most active group are situated in a syncline filled with the Grès de May. The Bagnoles group of moderate activity rise from a granite terrain, and the strongest radio-activity is found not in igneous, but in sedimentary rocks. The spring at Fay de Haut is strongly active, and, occurring in the granitic region, presents an anomaly. Superficial wells, etc., showed only very feeble activity. W. A. R.

HEAT.

517. *Method of Maintaining Small Objects at any Temperature between* − 180° *C. and* 20° *C.* **P. P. Cioffi and L. S. Taylor.** (Optical Soc. America, J. and Rev. Sci. Inst. 6. pp. 906–909, Oct., 1922.)—The method consists of surrounding the object to be cooled by a stream of cold dry air, while keeping any surfaces exposed to the free atmosphere above 0° C. The cold dry air is obtained by evaporating liquid air in a Dewar flask by an immersed electric heater. The cold air is forced by the pressure thus generated past the substance under examination, through a vacuum-jacketed delivery tube. The temperature is regulated by changing the rate of evaporation of the liquid air, by varying the current through the heater. Owing to the separation of ice and solid carbon dioxide, the apparatus requires cleaning at intervals of about six hours. F. J. B.

518. *Fused Salts.* **W. Herz.** (Zeits. Elektrochem. 28. pp. 390–391, Sept. 1, 1922.)—According to C. Smith [Abs. 173 (1913)] and the author [Abs. 2074 (1922)], all liquid and gaseous substances should, at the critical temperature, have the same refractive index, 1·126. Calculations based by the author and R. Lorenz (Zeits. Anorg. Chem. 117. p. 103, and 120. p. 320) upon the determinations by G. Meyer [Abs. 1800 (1922)] of the refractive indices of fused potassium and sodium nitrates, viz. 1·136 and 1·138, show that this holds also for fused salts. Further, calculations of the boiling points from the surface tensions agree with Wartenberg's values [Abs. 1161 (1922)], except for caesium fluoride. According to van der Waals and Walden, the ratio of the surface tension at boiling-point γ_s to the critical pressure p_k should be 0·45; the author calculates $p_k = \gamma_s/0{\cdot}427$ from Jaeger's experiments on alkali salts. The resulting critical pressures would be high, $p_k = 338$ atmos. for LiF, and those values are probably only lower limits. Accepting these values, the author finds that the constant of Cederberg's vapour-pressure formula would approximately be 4·57, though it may vary considerably (extremes are 3·36 and 7·4). The author finally points to regularities in the differences between the melting- and boiling-points of the alkali haloids. H. B.

519. *Vapour Pressures of Salts.* III. **H. v. Wartenberg and O. Bosse.** (Zeits. Elektrochem. 28. pp. 384–387, Sept. 1, 1922.)—The experiments are continued [Abs. 1161 (1922)] with haloids and sulphides of silver, copper, lead, thallium, in apparatus of platinum or quartz, both melting- and boiling-points determined, and formulæ for the vapour pressures (log P) deduced. In the case of thallium the usual order of the boiling-points was found reversed, i.e. the fluoride showed the lowest boiling-point and the iodide the highest; there was decomposition, however, preventing exact determination. No boiling was observed in the cases of $BaCl_2$, $CaCl_2$, $CaBr_2$, and B_2O_3, even at temperatures ranging between 1536° and 1546° at pressures ranging from 62 up to 180 mm. in the different cases. It had formerly been stated that the fluoride vapours contained double molecules. Vapour density determinations made with about 3 mg. of salt in a Nernst apparatus do not confirm this; it is very difficult to expel all the hydrofluoric acid from the acid salts without risking contamination of the salt by the CO_2 of the atmosphere; but double molecules do not appear to be formed, except perhaps in the case of PbF_2. The decomposition temperature of the acid alkali fluorides rises with the atomic weight, from below 200° in the case of LiF . HF to above 550° for RbF . HF. H. B.

520. *Vapour Pressures and Heats of Vaporisation of Non-Associated Liquids.* **F. S. Mortimer.** (Am. Chem. Soc., J. 44. pp. 1429–1435, July, 1922.)—Empirical methods for evaluating the constants in the vapour-pressure and sublimation-pressure equations, $\log P_v = C_v - S_v/T$ and $\log P_s = C_s - S_s/T$, are given and their significance discussed. It is shown that S_v, the slope of the log P with 1/T curves is, for normal liquids given by the expression, $S_v = -68 + 4 \cdot 877\, T_b + 0 \cdot 0005\, T_b^2$. It has been made evident from experimental data that the molecular heat of vaporisation is equal to $4 \cdot 23 \times S_v$ rather than $4 \cdot 58 \times S_v$. It is shown that the values of the molecular latent heat of vaporisation calculated from the equation $L_v = 4 \cdot 23\, S_v$, are generally in better agreement with the experimental results than those calculated from the equations proposed by Trouton, by Bingham, or by Nernst. The advantage is especially marked when applied to substances boiling at high temperatures. The thermodynamical equations relating heats of vaporisation, of sublimation, and of fusion and their relation to the vapour pressure and sublimation pressure are briefly reviewed and empirical methods for calculating each from the freezing- and boiling-points for normal liquids are proposed. AUTHOR.

521. *Vapour Pressure of Solid Zinc and of some Copper-Zinc Alloys.* **L. Guillet** and **M. Ballay.** (Comptes Rendus, 175. pp. 1057–1058, Nov. 27, 1922.)—The vapour pressure of a 55/44 copper-zinc alloy is much greater in a reducing atmosphere than in an oxidising one, *e.g.* at 800° C. in air the pressure is 1·19 mm. of mercury and in hydrogen 10·57. In the former case a skin is formed on the metal, but not in the latter case. In the case of pure zinc the pressure rises from 3 mm. at 535° C. to 19·32 mm. at 630° C. J. L. H.

522. *The Absolute Values of the Entropies of Gases and their Relative Changes in Magnitude.* **V. Njegovan.** (Zeits. Elektrochem. 28. pp. 313–322, July 1, 1922.)—It is only quite recently that, thanks to the work of Nernst and Planck, we have been able to obtain the absolute value of the entropy of a gas. Denoting entropy by S, the thermodynamic equation $S = C_v \log T + R/m \log v + \text{const.}$, or if the volume is constant $S_v = C_v \log T + \text{const.}$, is discussed with the help of a diagram. Nernst's heat theorem is used to obtain the value of the integration constant in the entropy equation, and the entropy at constant volume is calculated for several gases. Values of temperature, C_v, and S_v are tabulated together with the ratio S_v/C_v. This ratio is found to be nearly constant, increasing slowly with temperature. C_v and S_v are plotted against T, and the curves are seen to be nearly parallel to one another. The case of a perfect gas is now considered, and it is concluded that the absolute value of the entropy is a constant characteristic of the gas in the same way that the heat capacity is. The author then proceeds to the consideration of irreversible processes, and after discussing the criterion for an irreversible process as given by Clausius and Planck, endeavours to show that an increase of volume or surface may be equally well considered as criteria for an irreversible process, and that this is in agreement with Boltzmann's definition of entropy or Ostwald's "Extensität." T. B.

523. *Anomalies of the Expansion of Glass.* **P. Lafon.** (Comptes Rendus, 175. pp. 955–958, Nov. 20, 1922.)—The measurements are made by the differential method of Chevenard upon specimens 46 mm. long, compared with a bar of soft steel of the same length. The expansion curves for glass obtained in this way show four clearly distinct regions: at the beginning, a rectilinear part, the inclination of which depends upon the difference between the expansion of the glass and that of the steel; from this inclination the mean coefficient of expansion of the glass for the corresponding interval of temperature can be calculated. The curve next shows a hump corresponding to a smaller expansion of the specimen. Then the curve descends rapidly for a more or less considerable interval of temperature according to the nature of the glass. Lastly, the curve rises vertically again at the moment when the sample is soft enough to crush under a pressure of some grammes. The first anomaly corresponds to a diminution of the dilatation, and is due to the annealing of the glass, and may be looked upon as the superposition of an irreversible contraction upon the dilatation. The expansion which takes place before reaching the point of depression is reversible, and is sometimes important. The intensity of the phenomenon varies a good deal from one kind of glass to another. Lebedeff has pointed out the same phenomenon, and attributed it to the reversible transformation of quartz. He based this conclusion upon the fact that, in the glass he experimented with, the transformation in question was produced at 570°, like that of quartz. This explanation is now considered untenable, as the silica in the glass is in an amorphous state, and, in the glass now studied, the anomaly descends sometimes to 400°. This appears to be an allotropic transformation of the amorphous silica analogous to that observed with melted sulphur. This explains the absorption of latent heat often noticed when heating glass in the neighbourhood of the annealing temperature. A. E. G.

524. *An Alignment Chart for Thermodynamical Problems.* **C. R. G. Cosens.** (Cambridge Phil. Soc., Proc. 21. pp. 228–230, Nov., 1922.)—The "chart" consists of four vertical scales marked V, ϕ, T, P, respectively, and two identical horizontal scales marked n. The scales are so divided that any definite transverse line drawn across the four vertical scales cuts these scales in such points as to give simultaneous values of V (the volume of 1 lb. dry air, in cub. feet), ϕ (the entropy of 1 lb. dry air), T (the abs. temperature), and P (the pressure in lbs. per sq. inch). If two such "state lines" intersect one another on the index-line n', the corresponding states are connected by the equation $PV^{n'} =$ constant. The P, V, and T scales are logarithmic, corresponding to the equation above, or $\log P + n \log V =$ constant, and $PV = RT$ for $n = 1$. The horizontal scale is such that if A and B are its extremities, and C a point marked n', then $AC/CB = n'$. Also since $\phi = K_v \log P/P_0 + K_p \log V/V_0$, ϕ is a linear function of log P and log V, hence the scale of ϕ on the chart is an evenly divided scale. It lies along the index line $n = 1{\cdot}4$, since the adiabatic equation for air is $PV^{1{\cdot}4} =$ constant. The original chart, on a square of 18″ side, will give an accuracy about equal to that of a 10″ slide rule. T. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

525. *Quantum Theory and the Magnetic Field.* **A. Einstein** and **P. Ehrenfest.** (Zeits. f. Physik, 11. 1. pp. 31–34, 1922.)—Stern and Gerlach have described an experimental test of the applicability of the quantum theory to the magnetic field [Abs. 2121 (1922)]. In the present paper a discussion is given of the results obtained by Stern and Gerlach. Difficulties encountered in the interpretation of the results lead to two possible alternatives, and from both of these it is concluded that the results obtained by Stern and Gerlach cannot be regarded as satisfactory. A. W.

526. *The Lorentz Electron.* **I. Maizlish.** (Phys. Rev. 20. pp. 34–38, July, 1922.)—The author seeks to ascertain whether or no it be possible for Lorentz's electron, in addition to its contraction in the line of its motion, to undergo a uniform expansion or contraction proportional to $\lambda(\beta)$, a function of β, the ratio of its speed to that of light. He obtains general expressions for the longitudinal and transverse momenta and masses of such an electron from which he shows that for a uniform expansion $a\beta/(a\beta + b\sqrt{1 - \beta^2})$, where a and b are arbitrary constants, the longitudinal mass of Lorentz's formula would be unaltered, but in order that *both* the longitudinal and transverse masses of Lorentz's formula should remain unchanged at all speeds, there must be no uniform expansion or contraction. G. W. DE. T.

527. *Potentials of Moving Charges.* **S. C. Kar.** (Phil. Mag. 44. pp. 376–379, Aug., 1922.)—The author derives a method for obtaining the expressions given by Lienard and Wiechert, which does not involve four-dimensional integration. The potentials due to the moving charge are expressed in terms of a system of axes moving with it. By a Lorentz transformation they are referred to axes at rest. The potentials due to a moving electron and a linear uniform current element are investigated. A. Wh.

528. *Principles of Electrodynamics.* **L. Puccianti.** (N. Cimento, 24. pp. 95–114, July-Aug.-Sept., 1922.)—A summary of the foundations of classical electrodynamic theory. A. Wh.

529. *The Problem of Two Electrified Spheres.* **A. Russell.** (Phys. Soc., Proc. 35. pp. 10–29; Disc., 29. Dec., 1922.)—It is shown that Poisson's method can be readily applied to get the complete solution of the problem of two electrified spherical conductors. The case of a spherical condenser is first considered, and simplified methods of computing its capacity are given. Simple expressions for the potentials at the two inverse points due to the charges on each of the spheres are found. Poisson's method is then used to show that the capacity coefficients for two spheres external to one another can be very simply expressed in terms of the capacities of certain spherical condensers and can thus be readily computed in all cases. Formulæ for the attraction and repulsion of two electrified spheres are given. When the charges are of like sign the electrostatic energy of the system has a maximum value when the spheres are at a given distance apart. Similarly, when the potentials are of like sign and maintained constant, the electrostatic energy of the system has a minimum value for a definite distance between them. The particular case when the spheres are close together is considered in detail. The exactly analogous problems in thermal and electric conduction are also considered, and it is shown how their solutions can be written down at once. Finally, the formula for the maximum value of the electric stress in the medium surrounding the spheres is given and its practical importance is pointed out. For equal spherical electrodes at a fixed distance apart there is a definite size of radius which makes the disruptive potential difference a maximum. The distance between them where the attraction has a maximum value is also found. AUTHOR.

530. *Charge on Non-Conducting Plates by Rubbing.* **A. Prati.** (Accad. Lincei, Atti. 31. ii. pp. 478–481, Nov. 19, 1922.)—The arrangement adopted by Cardini [see Abs. 2125 (1922)] when investigating the electric charge by means of the phenomena of ionisation and, reciprocally, that phenomena by means of the charge, has suggested the experiments here described. A qualitative and quantitative study is now made, with a ballistic galvanometer, of the charge which accumulates on a non-conducting plate by stroking one face, say with wool, and holding the other in contact, or not, with an armature in communication with earth. The substances experimented with include sulphur, ebonite and sealing-wax. The results given show that at first the quantity of electricity increases almost proportionately to the number of strokes, then a true state of electrical saturation of the plates is rather rapidly approached. These results are in accord with those obtained by Cardini and also with those of Morris Owen. A. E. G.

DISCHARGE AND OSCILLATIONS.

531. *Dielectric Strength of the Vacuum. Electrostatic Ionisation Gradient of Metal Electrodes.* **J. L. R. Hayden.** (Am. I.E.E., J. 41. pp. 852–853, Nov., 1922.)—The dielectric strength of air at 0° C. and 76 cm. pressure is 30 kv. per cm. It is proportional to the air density over a considerable range, reaches a minimum for a moderate vacuum, and in a high vacuum reaches high values. The dielectric strength of a perfect vacuum would be the voltage gradient which, by its electrostatic stress expels from the electrodes ions alone or ions and metal vapours; in other words, the ionisation gradient of the metal electrodes. Experiments were carried out to determine the sparking voltage between 1 cm. spheres in the most perfect vacuum attainable with modern methods of exhaustion. In the final tests an 8-in. kenotron bulb was used, the spheres and connecting shanks being of highly polished molybdenum, and the distance apart of the spheres 0·306 cm. After two days' exhaustion with a Langmuir pump, the dielectric strength was calculated to be 1235 kv. per cm., the effective 60-cycle voltage required to jump the gap being 213 kv. An attempt to cool the bulb by liquid air resulted in cracking the glass, and the experiments were discontinued. A. W.

532. *Luminosity Produced by Electric Discharges in Tubes Containing Gases at Slightly Reduced Pressures.* **G. Nakamura.** (Kyoto Coll. Sci.

Mem. 4. pp. 383–391, May, 1921. In English.)—Electric discharges through tubes containing air, hydrogen, or coal-gas at pressures of a few cm. were examined with a falling plate camera, and the apparently unstriated discharges consisting of a number of luminous bands were studied. The results obtained by using a rotating mirror as an analyser are shown in a series of photographs obtained by the camera with the falling plate. In some cases vibrations of a tuning-fork were recorded simultaneously on the photographic plates to determine the velocity of the latter. The photographs appear to show that the luminosity was set up in the neighbourhood of the anode, and thence proceeded to the kathode. The facts observed, however, show that the luminosity is not due primarily to the anode, but it is caused by ionisation due to electrons coming from the kathode. The phenomena noticed, viz. that the luminous bands got broader as the pressure was increased, that the kathode ends were thicker than the remainder, and that the kathode side of the band was brighter and lined by a thin but bright layer, all agree with the mode of explanation suggested. This is confirmed by further observations made when the tube was excited by an induction coil. Photographs of these results are given. The explanation of the formation of the luminous bands is summed up thus: As the p.d. acting on the terminals of the discharge tube is increased, positive ions bombarding the kathode will produce a number of electrons which, driven by an intense electric field in the neighbourhood of the kathode, will acquire sufficient kinetic energy to make the gas luminous. By this process they lose their velocities and consequently their path becomes dark. But they soon regain sufficient energy after having travelled through certain distances, and then they make the gas luminous again. By repetition of this process alternately dark and bright spots are produced. Thus for a single partial discharge the distance between bright and dark spots should be nearly equal, and it should increase as the p.d. between the terminals is lowered. This is seen to be the case in the photographs illustrating the paper. The author notes that while his paper was in the Press communications appeared on a similar subject by Aston and Kikuchi. [See Abs. 128 (1921).] J. J. S.

533. *The Negative Discharge Precedes the Positive.* **K. Przibram.** (Akad. Wiss. Wien, Ber. 129. 2a. pp. 151–160, 1920.)—The author has previously shown [see Abs. 1318 (1920)] that the discharge figures are formed more quickly by the anode than by the kathode, but that the latter begins earlier. Pedersen has now shown that the positive figures extend quicker than the negative. With the help of Pedersen's results the author shows that the positive discharge path must be a better conductor than the negative, and he further comes to the conclusion that the connection between form and velocity of spreading out, as is evident in the electrical figures, is a special case of a general morphological rule. A diagram illustrating relative positions of positive and negative poles is given, and the experiments described show (1) that the alteration of the angle between the electrodes makes no noticeable difference in the relative times of discharge; (2) for a plate thickness of 1·4 mm. no difference occurs for spark-lengths of 2, 3, 5, or 9 mm.; (3) on the other hand, with increasing thickness of plate there is a considerable increase in the time the negative precedes the positive ($2{\cdot}1 \times 10^{-8}$ sec. to $7{\cdot}4 \times 10^{-8}$ sec.) for a primary spark-length of 5 mm. It is concluded that further research is necessary on the dependence of the times of discharge upon the research conditions. It, however, appears certain that under the conditions here described the negative discharge precedes the positive by about 2×10^{-8} seconds. A. E. G.

534. *"Mass-Proportionality" of Kathode-Ray Absorption at Mean Velocities.* **A. Becker.** (Ann. d. Physik, 67. 5–8. pp. 428–461, June 29, 1922.)—The question of the dependence of the absorption ability for moderately rapid kathode rays on the mass is here considered and experimentally investigated. The experimental arrangements are described in detail and illustrated diagrammatically, and the results are given in tabular and graphical form. It is found that all the elements experimented with, namely, H, C, Cl, Br, show deviation from the "Mass proportional" law in the sense of greater absorption, the greatest deviation being shown by H, the least by C. These properties of the elements are repeated in all their compounds. As a first approximation the atomic properties are additive, as has been previously shown by the author, Lenard, and Silbermann, who has proved this for complicated compounds. The present research shows, for the first time, that this conclusion remains true when the influence of velocity is taken into consideration. In a second approximation the influence of the arrangement or combinations of the atoms seems to be perceptible. There is the same connection between the mass and loss of velocity as there is between mass and absorption in the limits of the present experiments. A. E. G.

535. *The Spark Potential Difference between Spheres.* **U. Yoshida.** (Kyoto Coll. Sci., Mem. 5. pp. 97–110, Dec., 1921. In English.)—The maximum intensity between equal spherical electrodes has been worked out by Schuster and Russell, and is expressed by the equation $V = R_m x/f$ where V is the potential difference, x the distance apart of the spheres, R_m the maximum intensity, and f a factor depending upon the diameter of spheres ($2a$) and upon x, and whether one electrode is earthed or not. The author has analysed the experimental results between two equal spheres by Algermissen, Paschen, Heydweiller, and Orgler in the case of the gases air, hydrogen, carbon dioxide, nitrogen, and oxygen, and under the conditions of both spheres insulated and also one being earthed. He has evolved a general formula of the following type, $V - C = R_m \times \dfrac{1 + b\left(\dfrac{x}{a}\right)^{\frac{1}{2}}}{f}$, where C, R_m, and b are constants. By using this equation, the correct results are in fair agreement with the average experimental results. The constant term C is the fall of potential between electrode and the gas, and the correcting factor $1 + b\left(\dfrac{x}{a}\right)^{\frac{1}{2}}$, the author supposes, is due to the presence of leading-in wires and other bodies in the neighbourhood of the spark-gap. J. L. L.

536. *The Thermionic Work Function of Tungsten.* **C. Davisson and L. H. Germer.** (Phys. Rev. 20. pp. 300–330, Oct., 1922.)—The equation $i = AT^{\frac{1}{2}}\epsilon^{-b/T}$, proposed by Richardson in 1902 to represent the current from a thermionic source as a function of temperature, has been found to be of general and precise application within the limits of error of such measurements. An account is given in this paper of measurements of the thermionic work function of pure tungsten made by two methods for the same segment of a uniformly heated filament simultaneously. The filament, diam. 0·00755 cm., had three finer tungsten leads welded to it 3·85 cm. apart, and was kept stretched by means of a molybdenum spring between two molybdenum plates used to apply an electric field and to receive the space current, the ends of the filament being surrounded by guard boxes to limit the emission to the section of the filament between the potential leads. All parts were sealed inside a tube and by alternately baking the tube and heating the metal parts the residual gas pressure during the measurements was reduced to about 10^{-7} mm. as observed with an ionisation manometer. (1) In the first method of measurement—the *calorimetric*—the equivalent voltage of the work function was computed from the equation

$$\phi = 2\mathrm{EI}(\Delta\mathrm{E}/i)/(\mathrm{E} - \mathrm{I}d\mathrm{E}/d\mathrm{I}),$$

where E is the voltage across the segment and I the current through it, and ΔE is the voltage change when the space current i flows from the filament, I being kept constant. Since ΔE was only from 10^{-3} to 10^{-4} times E, special precautions had to be taken to measure it with sufficient accuracy and to keep I sufficiently constant. Observations from 2070° K. to 2300° K. show an apparent increase for ϕ of about 2 per cent. in this range, considerably greater than is to be expected theoretically. At 2270° K. when correction is made for the asymmetry of the electric shielding (− 2·24 per cent.) and for the radiation from the plates heated by the space current (+ 4·12 per cent.) ϕ comes out $4{\cdot}91 \pm {\cdot}05$ volts. (2) In the second method—the *temperature variation method*—assuming Richardson's equation $\log i = \text{const.} + 1/2 \log \mathrm{T} - \phi e/\mathrm{KT}$, measurements of the emission in the range 1930° to 2300° K. gave for ϕ the values 4·87 or 4·78 volts according as the temperature scale of Langmuir or that of Worthing and Forsythe is adopted. The latter scale is probably more trustworthy, but gives a value of ϕ 2·7 per cent. less than the value obtained calorimetrically, a difference considered to be greater than the probable error of the measurements. The thermal energy of conduction electrons is supposed to be $\frac{3}{2}k\mathrm{T}$ by the classical theory upon which the computations of ϕ are based. If, however, the energy is taken to be practically zero, then the same data lead to 4·52 and 4·48 volts for the values of ϕ by the two methods, and the agreement is within the probable error of the measurements. J. J. S.

537. *Spectroscopic Investigation of the Ionisation of Argon by Electron Collisions.* **F. Horton** and **A. C. Davies.** (Roy. Soc., Proc., 102. pp. 131–150, Nov., 1922.)—In referring to their previous investigations [see Abs. 718 (1920), 294 (1921), 545 (1922)] of the effects of electron collisions with argon atoms, in which the production of radiation and ionisation was looked for, using an electrometer as detecting instrument, the authors point out the discordant values obtained by other observers for the critical ionisation voltage, and suggestions are put forward in an attempt to account for the lack of agreement. In the present work the spectroscopic method of testing for ionisation is employed. The apparatus used is described and the results obtained given in tables and graphs. The authors' previous determinations of the minimum electron energies for the production of resonance radiation (11·5 v.) and ionisation (15·1 v.) are confirmed and the energy necessary to remove two electrons simultaneously from a normal argon atom is found to be 34 v. Many lines in the blue spectrum of argon appear simultaneously with the occurrence of double ionisation, but others need a greater electron energy for their stimulation, and therefore probably require for their production the removal of more than two electrons from the normal atom. Stark's classification of certain of the lines of the blue spectrum as "bivalent" and others as "trivalent" is not supported. It appears probable that the ionisation voltage is related to one of the M X-ray absorption limits of the various elements in a manner analogous to that in which the helium ionisation voltage is related to the K absorption limits and the neon ionisation voltage to the L absorption limits. A. B. C. L.

538. *Theory of Ionisation by Cumulative Action and the Low-Voltage Arc.* **K. T. Compton.** (Phys. Rev. 20. pp. 283–299, Oct., 1922.)—In two recent papers the author has dealt with the impossibility of explaining low-voltage arcs by ionisation of gas molecules by single electron impacts [Abs. 1470 (1920) and 1684 (1922)]. By a low-voltage arc is meant one which strikes and operates at a voltage less than the minimum ionising potential of the gas. The phenomena seem to require for their explanation ionisation of gas molecules in successive stages by two or more separate agents. The term "cumulative ionisation" has been given to such effects and Hughes has given a survey of the subject in his recent report on Photo-electricity [National Research Council Bull. Vol. 2. No. 10].

(1) *Theory of Ionisation.*—The phenomena of the low-voltage arc seem to require for their explanation ionisation of the gas molecules in two or more successive stages. It is supposed by the author that each electron from the kathode after falling through a minimum potential difference reaches an active zone in which it collides either with a neutral molecule partially ionising it or with a partially ionised molecule which thereby becomes completely ionised. Each molecule when partially ionised emits a quantum of resonance radiation, and this may go off in any direction and will in a short distance be absorbed by a neutral molecule which thereby becomes partially ionised and emits another quantum of radiation. So the passage through the gas of the quanta of resonance radiation initially set free by electronic impacts is analogous to the diffusion of foreign gas molecules. *Equations for the case of coaxial cylindrical electrodes* are derived for the proportion of molecules partially ionised (1) by direct impact, and (2) by resonance radiation in terms of quantities which can all be readily measured except τ the mean life of the ionised molecules and $1/\rho$ the scattering coefficient for the radiation, for which (except ρ for mercury) only upper and lower limits can be estimated. The substitution of experimentally determined values leads to the conclusion that under normal circumstances partial ionisation by photo-impact is many times as great as that by electronic impact alone and is necessary and sufficient to account for the observed ionisation. The possibility of complete ionisation by successive photo-impacts alone is also discussed.

(2) *Theory of Low-Voltage Arc.*—If N_0 is the number of electrons emitted and P_0 is the proportion of partially ionised molecules in the active zone, N_0P_0 is the number of molecules ionised per second. Since

the positive ions move more slowly than electrons, each positive ion neutralises the space charge due to $4\surd(2 \times 1840M)$ electrons; hence the electronic current increases to $1/(1 - 242P_0\sqrt{M})$ times the value it would have without ionisation, provided the current is limited by the space charge around the kathode. As P_0 is increased by increasing the temperature of the filament or the applied potential, the current first increases to the saturation thermionic current, then the negative space charge is replaced by a positive space charge, the potential drop becomes concentrated near the kathode, the temperature of the kathode is raised by bombardment by positive ions, increasing N_0 and hence P_0; as a result the current increases at an accelerated rate, instability is usually soon reached, and the arc strikes suddenly. The chief function of the gas is to give the positive space charge around the kathode which is the distinguishing feature of the arc. If n is the saturation value of thermionic emission, the maximum current will be $\frac{3}{2}ne$ or $2ne$ depending on whether the voltage is below or above the minimum ionising potential. In the case of the *low-voltage arc in mercury vapour*, recent experiments indicate that the *striking voltage* is about 5·6 instead of 4·9 volts and that the arc may be dependent on either the 4·9-volt (2536 Å.) or the 6·7-volt (1849 Å.) radiation, according to the age of the vapour. Thus there seems to be *two meta-stable states of the neutral mercury atom*. The author suggests that resonance radiation must also be the chief factor in temperature ionisation both in the electric furnace and in the sun and other stars. J. J. S.

539. *Ionisation of Abnormal Helium Atoms by Low-Voltage Electronic Bombardment.* **F. Horton** and **A. C. Davies.** (Phil. Mag. 44. pp. 1140–1146, Dec., 1922.)—The authors make use of the apparatus described by them in Abs. 545 (1922). Abnormal helium atoms were obtained in the main tube of the apparatus by the action of radiation, which entered it from an auxiliary side tube, where it was produced by bombardment of the helium with an electron stream. This radiation passed into the main tube by the process of absorption and re-emission by other helium atoms. Electrons and positive ions were prevented from passing out from the side tube by an arrangement of electric fields. The abnormal atoms were bombarded, in the main tube, by a stream of electrons, the energy of which could be gradually increased, and although complications arose owing to re-combination between the bombarding electrons and positive ions produced by the radiation from the side tube, evidence was obtained, by a rise in the ionisation current commencing at about 4·5 volts, that abnormal atoms can be ionised by electrons with this amount of energy. The fact discovered by Kannenstine that an alternating-current arc can be maintained, and even made to strike, in helium, provided the frequency exceeds a certain limiting value [Abs. 1896 (1922)] appears to be due to this cause, the interval between the breaking of the arc and the re-application of the energy necessary for the ionisation of the abnormal atoms having been sufficiently short for there to be still a considerable number of abnormal atoms present at the end of the interval. It is suggested that the energy of abnormal atoms may be absorbed and re-emitted by other atoms several times during the interval; and the period 0·0024 second, measured by Kannenstine, may not really be the "life" of an individual abnormal atom. It is not necessary to assume the metastability of any special abnormal state of the helium atom. H. N. A.

540. *The Minimum Potential of Electric Discharge in Gas at Low Pressures.* **E. Dubois.** (Comptes Rendus, 175. pp. 947–949, Nov. 20, 1922.)—Some time ago the author pointed out some peculiar variations of minimum potential in hydrogen at low pressures [see Abs. 1928 (1921)]. This was then attributed to gas occluded in the electrodes. Since then experiments have been conducted in oxygen and CO_2 with very refractory metals, such as tungsten and molybdenum, and the results obtained have led to the conclusion that most of the effects observed may be attributed to the presence of saline substance covering the electrodes. It appears that there is an initial minimum potential (V_A) for new electrodes (A) which can be altered to a much higher value by heating to whiteness the two electrodes for a few seconds. By alternating the measurement of V and the heating of the electrodes, the disruptive potential continues to increase, but tends rapidly to a new well-defined limit (V_B) corresponding to a new state of the electrodes (B). If one of the electrodes is in state A and the other in state B, they lead to disruptive potentials V_A or V_B according as one or other is taken as the kathode; the disruptive potential is therefore influenced by the nature of the kathode and not by that of the anode. The hypothesis which seems to fit in most perfectly with the facts is that the passage from one state to the other corresponds to the disappearance of a substance or mixture of substances impregnating the kathode. This supposition is found to be confirmed by experiments in which traces of salts are placed on the electrodes. The surface of the new metals is impregnated with impurities of all kinds and, although metallic salts may not be the only factor, it is certain they play an important part. The state B is that of the pure metal and the table of results given show that V_B is independent of the nature of the metal, i.e. V_B is the true disruptive potential of the metals. It is also found that the state B can be produced by allowing an intense and prolonged discharge to pass, the impurities acting at the surface of the electrode are thus detached by the discharge. The limiting values of V_B so obtained are found to be in good accord with those obtained after heating the electrodes to whiteness. A. E. G.

541. *The Determination of the Charge of Electrons by Means of the "Schrot" Effect in Thermionic Tubes.* **R. Fuerth.** (Phys. Zeits. 23. pp. 354–362, Sept. 15, 1922.)—Schottky has shown that the discontinuity of the current in a thermionic tube, due to the fact that it is carried by electrons of definite charge, will set up vibrations in a suitably tuned circuit in parallel with the tube. He compares the stream of electrons with a stream of small shot (schrot) and gives the name schrot-effect to the phenomenon [Abs. 1920 (1921)]. Hartmann has attempted to measure the charge of an electron in this way, finding the effective voltage V′ required to produce a pure note of equal intensity to that heard in a telephone connected with the thermionic tube circuit; and deducing from this the effective voltage, $\sqrt{\overline{V^2}}$ of the condenser in this circuit. The values obtained are not very satisfactory, as they vary with the frequency, and do not agree with the accepted value. The author gives a revised theory of the phenomenon, which is simpler than that of Schottky, and which, when certain corrections are made in the latter's formulæ, lead to the same result. If Z_0 is the impedance of the resonating circuit, R the resistance, L the inductance, i_0 the saturation current, and ϵ the electronic charge, $\sqrt{\overline{V^2}} = Z_0\sqrt{\epsilon R i_0/2L}$; the effective value of the current in the resonating circuit is given by the equation $\sqrt{\overline{i^2}} = \sqrt{\epsilon R i_0/2L}$. The corrected theory, however, does not at once give the true value of the electronic charge. The note heard in the telephone is not due to a pure sine wave; but to an irregular series of vibrations; and it is therefore not possible to deduce $\sqrt{\overline{V^2}}$ from V′ in the simple manner adopted by Hartmann. To do so it is necessary to know the minimum stimulus required to produce a sensation for each of the notes experimented with. This was determined for the range of vibration frequencies employed by Hartmann, It was shown that for physiological reasons, and reasons connected with the properties of the telephone, the minimum varies in a remarkable manner with the frequency; and, although it is probable that the variations are not quite the same for different observers, it was found that when $\sqrt{\overline{V^2}}$ was calculated from Hartmann's readings, using the results obtained, a very fair agreement with the accepted value of the electronic charge was reached, throughout the range of frequency employed. H. N. A.

542. *Electric Spectra and Conveying Motions in the Discharge.* **G. Piaggesi.** (N. Cimento, 24. pp. 39–44, July–Aug.–Sept., 1922.)—There are many known methods for materialising the lines of force in an electric field; one of the best is probably that of Kolbe. This method consists in projecting a vessel containing a suspension of crystals of sulphate of quinine in essence of rectified turpentine, and two electrodes connected with the poles of an electrostatic machine. These experiments are now repeated with a vessel with parallel faces, and filaments of asbestos, 2–3 mm. in length, are suspended in oil of vaseline. Photographs are given, which show the results obtained with this arrangement. To observe the conveying motion in the discharge, and so to get some idea of the motion of ions in the electric field, minute file dust of aluminium is substituted for the asbestos, and it is found also that by this means phenomena are obtained in vaseline which correspond to the electric wind. A. E. G.

543. *The Electric Arc as a Rectifier.* **S. Borowik.** (Phys. Zeits. 23. p. 362, Sept. 15, 1922.)—If one electrode is covered with iron oxide, the other being of carbon, only that phase of an a.c. passes for which the iron oxide serves as anode. The action is constant for currents of 2 to 20 amperes, and from 100 to 1500 volts. The valve action was also observed with an induction coil. There was an intense emission of positive ions when the oxide was raised to a high temperature at + 100 volts. An a.c. arc cannot be formed between two iron oxide electrodes. H. N. A.

544. *The Unilateral Passage of Current in the Electric Arc Due to a Difference of Temperature between the Electrodes.* **L. Dunoyer** and **P. Toulon.** (J. de Physique et le Radium, 3. pp. 389–400, Nov., 1922.)—According to Blondel [see Abs. 680 (1899)], the arc may present two régimes: the short arc, which is stable and for which the tension at the terminals of the arc and the current through it are alternatively of opposite sign but symmetrical; the long arc, which is more unstable and in which the current only passes in one direction, from metal to carbon. Blondel's experiments have been repeated and confirmed, but it now seems that polarity or symmetry does not depend upon the length of the arc. The results obtained seem to indicate that it is the temperature of the copper electrode which governs the phenomena; whatever may be the length of the arc, while the copper electrode is cold it functions only as anode. In order to demonstrate this, experiments are carried out with water-cooled electrodes, one set with two electrodes, one of which is cooled, another with three electrodes, two of which are carbons placed horizontally and the third is fixed vertically above them and is water-cooled. Both these arrangements are described in detail with diagrams. A table of results is given and it is shown from these that, for a given length of arc, there is a limiting alternating tension above which the valve effect is imperfect; and a rectifying arrangement with several anodes is also described. The conclusion arrived at is that the apparent paradox of the Garbarini arc may be accounted for, not by considering the temperature of the kathode as a whole, but the temperature of certain regions, probably extremely small. In an addendum, more recent work of Blondel is discussed. The explanation he gives of the peculiar behaviour of this arc is that a part of the carbon vaporised by the anode is constantly being deposited on the kathode and that this extremely thin layer may easily attain incandescence. It is hoped to be able to carry out spectroscopic observations to determine whether there is any ground for such a supposition. [See also Abs. 2314 (1922)]. A. E. G.

545. *Generation of Polyphase H.F. Oscillations by Valves.* **R. Mesny.** (Comptes Rendus, 175. pp. 691–692, Oct. 23, 1922.)—A description is given of a method of generating polyphase oscillations using a number of valves coupled together. A diagram is exhibited showing the method applied in the case of 3 valves, i.e. 3-phase oscillations. In the anode and grid circuits of each valve is inserted an inductance and the grids of the valves are joined by condensers. When the homologous elements of the circuits are slightly different, stability ensues and oscillations of one frequency are generated. If the difference between the elements exceeds 4 or 5 %, there are several frequencies present. N. W. M.

546. *Short Electric Waves.* **R. Whiddington.** (Phil. Mag. 44. p. 1064, Nov., 1922.)—Describes an alternative method to that of Gill and Morrell [see Abs. 2444 (1922)] for obtaining short waves from a valve generator. The grid circuit has the usual capacity-inductance unit, but the anode circuit is merely a loop of wire. The necessary coupling between the grid and anode circuits to secure the condition for oscillations is due to the inherent capacity between the valve electrodes. N. W. M.

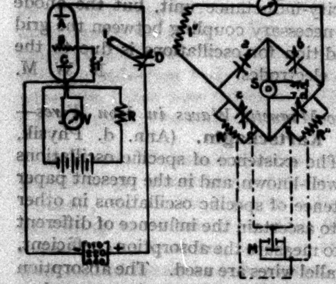
547. *Selective Absorption of Electro-Magnetic Waves in Iron Wires—Magnetic Permeability of Iron.* **W. Kartschagin.** (Ann. d. Physik, 67. 4. pp. 325–336, May 23, 1922.)—The existence of specific oscillations in the region of small wave-lengths is well-known, and in the present paper an attempt is made to prove the existence of specific oscillations in other wave-length regions also, and further, to ascertain the influence of different kinds of iron. The method employed to measure the absorption coefficient, γ, of the waves is that in which two parallel wires are used. The absorption coefficient was calculated by means of the wave energy values ϵ_1 and ϵ_2 at two points x_1 and x_2 in the two parallel iron wires through the formula $\gamma = 2 \cdot 3 \log_{10}(\epsilon_1/\epsilon_2)/(x_2 - x_1)$. [See Abs. 633 (1919).] The absorption coefficient, γ, has been determined for waves of 2 to 42 metres long. For brass wire the observed γ is proved to be equal to that calculated according to a given formula. A selective absorption of wave energy is found in iron wires for the wave region considered. The probable magnetic permeability of the iron is calculated according to the values of the absorption coefficients. By this means the magnetic permeability is found to vary from 1·13 to 219 and to differ for different diameters of wire. [See also Abs. 1470 (1921).] A. E. G.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

548. *Conduction in Soda-Lime Glass.* **C. A. Kraus** and **E. H. Darby.** (Am. Chem. Soc., J. 44. pp. 2783–2797, Dec., 1922.)—The conduction of lime-soda glass at temperatures between 200° and 350° C. was studied, and the passage of different metals and the effects on the glass were noted. It was found that sodium and potassium enter the glass from the fused nitrate, but copper, lead, zinc, and silver do not enter the glass readily, and the glass is liable to disintegrate badly and crack, when these metals enter the glass.

Further it was found that 74 % to 82 % of the total sodium present in an ordinary soda-lime glass takes part in the conduction process, the remainder being either not charged or the ions are held in a fixed position. F. J. B.

549. *Specific Inductive Power of Colloidal Solutions.* **J. Errera.** (J. de Physique et le Radium, 3. pp. 401–410, Nov., 1922.)—The centre of dispersion and the phase dispersed in a colloidal system have as a rule a different specific inductive power. To determine this the author has employed the method of Nernst, wherein the capacity of a vessel filled with different substances is measured on a bridge. The magnitude of this capacity is a measure of the specific inductive capacity. The apparatus employed consists of a three-electrode tube utilising high-frequency alternating current (undamped waves), transmitted by induction to a bridge. The filament C is heated by a current of about 2·5 amps. from an 8-volt battery. The anode A can be raised to a potential of 110, 220, or 440 volts. An oscillating circuit, formed by a self-inductance I and a variable capacity D is interposed in the anode circuit. A reaction coil I′ in the circuit of the grid G allows oscillations to be obtained in the circuit ID. The bridge consists of four variable air condensers, *a, b, c, d*; a receptacle M for the solutions; and electrolytic resistances R′ and R″ having a negligible capacity. Two ends of the bridge are coupled to a coil I″, in series with a sensitive ammeter L; the other two ends are connected to the zero indicator S, to which is attached a telephone T. The capacities *a* and *b* are each exactly 500 cm.; *c* and *d* are about 1000 cm. The vessel M, empty, is first placed in parallel with the capacity *d*, and by increasing capacity *d* only, an adjustment is made to zero; then M is placed in parallel with capacity *d* and by diminishing *d* only, adjusted again to zero. The difference is taken as a measure of



the capacity. The specific inductive capacity is calculated from the formula

$$\mu_x = (\mu_1 - 1)\frac{C_x - C_0}{C_1 - C_0} + 1$$

where C_0 is the capacity of M filled with air; C_1 the capacity with a standard substance; and C_x the capacity of the unknown substance; μ_1 is the specific inductive power of the standard substance. The author describes tests of various substances, and gives his results in a series of tables and curves. T. C. H.

550. *Proportionality of Photo-Electric Current and Lighting with very Thin Potassium Layers.* **H. Geitel.** (Ann. d. Physik, 67. 5–8. pp. 420–427, June 29, 1922.)—The photo-electric behaviour of extremely thin layers of potassium is described. The thin layer of potassium is precipitated upon a layer of silver and the anode wire is of platinum. When such a cell is included in the circuit with a high-tension battery and a galvanometer, and is then illuminated with an incandescent lamp, the galvanometer shows a photo-electric current which is proportional to the incident energy for every wave-length of the effective light. The experimental arrangement is described with the aid of a diagram and the results are given in tabular form. A. E. G.

551. *Transformation of Thermal Radiant Energy into Electric Current in Molybdenite.* **W. W. Coblentz.** (Washington Acad. Sci., J. 12. pp. 411–412, Nov. 4, 1922.)—Certain spots in molybdenite give a high e.m.f., when radiant energy falls on them. This is a function of the intensity and the wave-length of the radiant energy, and of the thickness of the crystal. The maximum effect is produced by $\lambda = 0{\cdot}6$ to $0{\cdot}8$ micron. No e.m.f. was found for $\lambda > 1$ micron. These spots do not always coincide with those showing change of electrical resistance, when radiant energy falls on them, though there may be some connection between the phenomena. H. N. A.

552. *Rotary Slide-Wire for Producing Uniform Variation in Potential Difference.* **S. J. Mauchly.** (Optical Soc. of America, J. and Rev. Sci. Inst. 6. pp. 852–858, Oct., 1922.)—The author describes a special form of rotary potentiometer for varying the p.d. between the two plates of a condenser at a constant and definitely known rate. The principal requirements to be satisfied are: (*a*) A slide-wire of sufficiently high resistivity and low thermal expansion to allow the use of the required p.d. without objectionable expansion and other thermal effects; (*b*) a supporting insulating cylinder of approximately the same thermal expansion as the wire; (*c*) a travelling contact and brushes at the ends of the cylinder; (*d*) provision for altering the speed of rotation of the drum and means for determining that speed; (*e*) convenient regulation of the p.d. applied to the slide-wire; (*f*) the rate of change in the p.d. between the travelling contact and either terminal of the slide-wire must be known and kept constant to about 1 part in 250 for periods of at least five minutes. The slide-wire is 25 m. of No. 25 annealed chromel wire wound in a spiral groove of 80 turns on a white marble cylinder. Each of the brushes is a single piece of phosphor bronze slotted into five strips. The travelling contact is a grooved brass wheel held against the wire by a stiff spring, mounted on a steel axis,

parallel to the axis of the cylinder, along which it slides as it follows the wire spiral. For details the original paper should be consulted. With the apparatus described it is possible to secure a variation in p.d. uniform to 1 part in 250 for values ranging from several millivolts per sec. to 0·1 volts/sec. with the absolute values known to higher accuracy. Both the constancy and accuracy could be considerably increased if necessary.
T. H.

553. *Capacity Changes in Electrometers Using Rotating Pointers or Needles.* **H. Hermann.** (Phys. Zeits. 23. pp. 386–388, Oct. 1, 1922.)—This paper is a mathematical investigation of 4 types of electrometer, viz. the Noack, the Braun, the Idiostatic, and the Heterostatic. The range of utility of each instrument is criticised, and a short section devoted to the derivation of capacity from the distribution of charge.
H. H. Ho.

554. *A Plane-Cylinder Electrometer for Absolute Measurements.* **L. Bouchet.** (Comptes Rendus, 175. pp. 950–952, Nov. 20, 1922.)—This electrometer is based upon the attraction of an electrified cylinder for an equally electrified plane. It can be used for measuring high potentials in absolute values. It can be easily constructed and presents no difficulty in manipulation. A description of the method of construction with details as to size of cylinder, etc., are given. A mathematical calculation is added which gives the attraction of the cylinder in absolute units. A table of results shows that this electrometer may be used to measure in absolute units differences of potential up to 60 electrostatic units, and, in the apparatus described, this can be accomplished with a separation of cylinder from plane by no more than 3 cm.
A. E. G.

555. *A New Kathode-Ray Oscillograph.* **F. Gill.** (Engineer, 134. p. 557, Nov. 24, 1922.)—The kathode of this instrument is an electrically heated, oxide coated filament; and, by adjusting the heating current, the rays can be focused sharply, so as to form a green spot on a fluorescent screen at the other end of the tube. The anode consists of a small tube, which is placed immediately in front of the kathode, so that the rays pass through it axially. They then pass between two pairs of parallel plates, placed at right angles to one another, the rays being deflected in a plane perpendicular to a pair of plates by an amount proportional to the difference of potential between the plates. Deflecting coils outside the tube may also be made use of. In the case of the original Braun oscillograph, about 30,000 volts were required, while with the instrument described only 300 volts are needed for operation. The characteristic curve of a thermionic valve can be determined, and the apparatus can also be used for examining the wave form of a.c. generators, for the accurate comparison of two frequencies, for the investigation of iron hysteresis, of modulation in radio-telephony, and the measurement of nerve reactions.
H. N. A.

556. *A Device for Recording Electric Contact, Using an Electron Tube Generator and a Radio-Frequency Spark.* **C. T. Zahn.** (Washington Acad. Sci., J. 12. pp. 412–416, Nov. 4, 1922.)—A rotating contact maker makes and breaks the contact at the filament terminal of a three-electrode tube generator, connected with an induction coil actuating a spark. The generator circuit is tuned to the secondary circuit of the induction coil by means of an adjustable condenser, the radio-frequency being about 300,000 cycles per second. A cylinder of carbon paper rotates in synchronism with the contact maker, and the spark passes from a needle point through the paper. The time of duration of the spark is registered by a series of dots, about a millimetre apart, and not by a continuous cut in the paper; the frequency of these dots is about 1/50 of that of the radio-frequency. The time during which contact is made is registered with an accuracy corresponding approximately to the distance between two dots. The method has been used to show that the time lag, in starting or stopping the generator, is not more than 1/2500 second. Instead of connecting the contact maker to the filament terminal, it may be connected across the ends of a resistance of about 10 ohms, sufficient to prevent the generation of radio-frequency current, which is inserted in the oscillating circuit of the tube. When the resistance is short-circuited by the contact maker, current is generated. This method avoids sparking at the contact. A method is suggested for recording automatically the pressure-volume curve of a gas-engine cycle, by means of this apparatus. H. N. A.

557. *Variable Resistor of Low Value.* **C. N. Hickman.** (Optical Soc. of America, J. and Rev. Sci. Inst. 6. pp. 848–851, Oct., 1922.)—A continuously variable resistance which is suitable for carrying a large current and which permits the use of an accurately calibrated scale is described. The variation of resistance is accomplished by substituting a manganin wire for a copper wire of the same length and diameter. Readings may easily be repeated to one ten-thousandth of an ohm on a resistance having a range 0·01 ohm, and the instrument remains constant to this degree of accuracy. The variation of inductance as the resistance is changed is negligible, being less than 0·001 microhenry for the total range of the resistance. T. H.

558. *Resistance Furnace of Molybdenum in Vacuo.* **P. Fleury.** (Comptes Rendus, 175. pp. 880–882, Nov. 13, 1922.)—A description is given of an electric furnace for use at 1700° C. (several cm. diameter and several decimetres high) in which the heating current passes through a molybdenum spiral wound on a tube of refractory material. Molybdenum is more easily fusible and is more volatile than tungsten, but is less fragile after heating. The hot wire is enclosed in a vacuum chamber (of which the inner wall is that of the furnace tube) so as to minimise oxidation and volatilisation of the molybdenum. A. B. W.

ALTERNATING CURRENTS AND MAGNETISM.

559. *A Graphical Representation of the "Swing" Phenomenon with Resistance, Condenser and Choke Coil in Series.* **L. Fleischmann.** (Elekt. Zeits. 43. pp. 1288–1290, Oct. 19, 1922.)—If straight lines are drawn through the origin, ordinates representing volts and abscissæ current, the lines for a particular frequency can represent the reactances and ordinates their terminal pressures. The total pressure is also obtained by a simple construction and its value can be plotted for various currents. For voltage resonance the reactance lines fall together through the origin. When iron is present in the choke coil, on account of saturation the value of the total pressure for various currents is considerably affected. Iron loss in the choke coil can be taken into account by assuming it to be a loss in a resistance shunted across the choke coil. The author gives the "swing" curves of total terminal voltage with current increase for three frequencies, 67·5, 75, and 87·5 respectively. He also shows by oscillograms that the graphical construction is not exact on account of harmonics; the current is not simultaneously of sinusoidal form, though the applied voltage may be such. [See also Abs. 936B (1915) and 324B (1917).] J. L. L.

560. *Analysis of Alternating Currents by Means of the Braun Tube.* **G. Joos** and **E. Mauz.** (Jahrb. d. drahtl. Tele. 19. pp. 268–276, April, 1922.)—This paper gives details of a graphical method of obtaining Cartesian curves from the figures obtained with a Braun tube whose field plates are shunted across an inductance and resistance in series in an alternating-current circuit, the magnetic field coils being in series with the inductance and resistance. A numerical example is given for the case of a 500-cycle alternator. [See Abs. 839B (1920).] A. W.

561. *Magnetic Susceptibility of Six Nitrogen Oxides.* **T. Soné.** (Tôhoku Univ., Sci. Reports, 11. 3. pp. 139–157, June, 1922. 62nd Report from the Iron and Steel Research Inst.)—The method of measurement is almost the same as that previously used [see Abs. 624 (1920)]. The following results were determined. Nitric oxide, NO, gas, specific susceptibility $48 \cdot 8 \times 10^{-6}$ at 20° C., a value agreeing with that found by Bauer and others. Nitrous oxide, N_2O, gas, $-0 \cdot 429 \times 10^{-6}$; contrary to Quincke's determination, this gas is found to be diamagnetic. Nitrogen tetroxide, N_2O_4, liquid, $-0 \cdot 276 \times 10^{-6}$ at $-15°$ C., a value which agrees with Pascal's [see Abs. 904 (1909)]. Nitrogen peroxide, NO_2, gas, $4 \cdot 54 \times 10^{-6}$ at 20° C. Nitrogen trioxide, N_2O_3, liquid, $-0 \cdot 206 \times 10^{-6}$ at 18° C., a value smaller than Pascal's. Nitrogen pentoxide, N_2O_5, solid, $-0 \cdot 332 \times 10^{-6}$ at 16° C. G. E. A.

562. *Effect of Magnetisation on the Photo-Electric Effect in Iron.* **G. Polvani.** (N. Cimento, 24. pp. 65–93, July–Aug.–Sept., 1922.)—T. H. Poole recently undertook some experiments to obtain some evidence that in ferromagnetic substances the magnetic and photo-electric electrons are the same. He stated in support of this identification that ferromagnetic phenomena, just as much as the photo-electric, depend on the state of chemical combination of the substance; that is to say, that both the photo-electric and magnetic classes of electrons in the atom of a ferromagnetic element are to be identified with the valency electrons, and hence we might expect the act of magnetising a body to have some effect on its photo-electric properties. The work of Poole is discussed in the introduction to the present paper. The experimental arrangement used in the present work is described in detail and illustrated diagrammatically. From the table of results it appears that there does not exist a variation of one per mille in the photo-electric current of iron as the effect of magnetisation, at least when the direction of this is normal to the surface. This result is discussed in relation to the constitution of the metals, to magnetisation, and to the photo-electric effect. A. E. G.

563. *Some Effects of the Magnetic Field on Liquids.* **M. Pierucci.** (N. Cimento, 34. pp. 45–63, July–Aug.–Sept., 1922.)—Thermodynamical considerations led Stefan in 1871 to foresee a variation in the specific heats of iron by the action of the magnetic field. In 1898 Du Bois, on the same basis, foresaw a change in the boiling-point of substances placed in strong magnetic fields. The experimental result was in each case very slight. But the instantaneous variation in temperature of a ferromagnetic or strongly diamagnetic substance (bismuth) on exciting and suppressing the field (Weiss effect) is very marked, and may amount to nearly a degree. Still more noticeable are the effects on the propagation of heat in solids. Strong fields may cause the heat conduction of ferromagnetic substances and of bismuth to vary by several units per cent., producing a curvature of the isothermic lines (Righi-Leduc effect). But ferromagnetism is a characteristic property of the solid state, and the diamagnetism of bismuth decreases rapidly with fusion. We may thus conclude that experiment has not found, nor theory predicted, any appreciable effect of the magnetic field on the thermal properties of bodies in a liquid state. The problem here considered is whether any effect, even indirectly, is produced on the thermal properties of liquids exposed to magnetic fields of sufficient intensity. Evidently no effect on the specific heats of liquids is to be looked for, having regard to the fact that iron itself modifies its specific heat only slightly even when exposed to very intense fields. Any great variation in the boiling-point of substances which are liquid at ordinary temperatures may also be left out of account. Thus two points are left for examination: (1) An eventual Weiss effect. (2) A possible change in the propagation of heat. The first is in the present case so slight as to be negligible. Non-metallic liquids having only a very small thermal conductivity, the problem is reduced to a study of the effect on convection. The magnetic field was produced by a large electromagnetic of the old Weiss type. A complicated system of water circulation protected the central part of the field, where the liquid under examination was placed, from the thermal radiations of the coils. The details of the apparatus are shown in two figures. Experiments with diamagnetic and paramagnetic liquids confirmed the theoretical reasoning, and led to the conclusion that an intense, not entirely uniform, magnetic field profoundly modifies, and in certain cases practically annuls, the convection of heat in liquids, causing them to behave in this respect almost like solids. E. F.

564. *Magnetic Screening and Reflection.* **F. Heiles.** (Elek. u. Maschinenbau, 40. pp. 477–479, Oct. 8, 1922. Extract from paper read before the Elektrot. Inst., Karlsruhe.)—In connection with the dispersion of lines of force in alternators, experiments were made which tested whether the magnetic field of a conductor which passes through an iron plate is affected by that part of the circuit which lies behind the iron plate. The plate used was more than a metre square and 1 cm. thick. A long brass rod carried a current of 70 amperes through the plate, and the magnetic effects were tested by ballistic galvanometer and test coil on reversing the current. A very small effect due to the iron plate was noted. The same held when the brass rod was bent away at right angles immediately behind the iron. The effect of neighbouring masses of iron on the inductivity of coils was also tested in order to find whether the principle of magnetic images held for a.c. as well as for d.c. The effect on a coil due to the presence of the iron plate was comparable with that obtained by passing the same current through another coil of the same size, the second coil being placed in the "image" position. [See also Abs. 1132 (1901).] G. E. A.

565. *The Magnetic Transformations of Iron and Steel.* **P. Dejean.** (Ann. d. Physique, 18. pp. 171–272, Sept.–Oct., 1922.)—A long paper which deals with the history of the subject from Gilbert onwards and concludes with a bibliography which extends to thirteen pages. A method is described by means of which the magnetic induction of a specimen in a constant field is automatically recorded in terms of the temperature. The method is applied to the study of a series of steels with carbon content varying from 0·06 to 1·66 per cent. Some of the results obtained are as follows. The magnetic transformation of cementite takes place near 200°. The induction-temperature curve for a specimen with weak demagnetising field brings out the critical points A_1 and A_2. The nature of the transformations at these points is such that A_2 is reversible, but not A_1. An extra-soft oxidised steel was found to possess much hysteresis; the anomaly disappeared by heating at 250°, but reappeared on cooling. When a hard steel quenched in water was reheated, the induction in constant field passed through a maximum at about 300°, which is related to the anomalous expansion observed at the same temperature. The general form of the induction-temperature curves depends on the dimension ratio. When the latter is small, the induction is independent of the temperature until on reaching the point A_2 it falls rapidly to a very small value. This magnetic change is reversible for all steels in which A_2 is independent of A_3; but for those steels in which the A_3 point has been lowered sufficiently to affect A_2 and confuse it with A_1, the fall in induction occurs at this point A_{123} and is, like it, irreversible. For soft steels in which A_1 is independent of A_2 and A_3, no change of induction is noted at A_1. With specimens having weak demagnetising fields, two cases are distinguished: When the applied field is less than the coercive force, induction increases with temperature until near the critical points, when it diminishes rapidly to A_1 then to A_2 or A_{23}. When the applied field is considerably greater than the coercive force, the induction diminishes as the temperature rises; the diminution is accentuated at A_1 then at A_2 or A_{23}.

The second chapter deals with the demagnetising field, and observations are made on a ring and a number of bars with different dimension ratios, all from the same ingot of steel with 1·3 % C. Three demagnetising factors are distinguished which are calculated from the I, H and I′, H curves (I, true intensity; I′, apparent intensity). These factors are practically constant for the range of I from 300 to 800.

The intensity of magnetisation corresponding to the saturation of a short cylinder is the same as that for an infinite cylinder, and is reached without much difficulty. Hence in electromagnets with strong magnetising fields, large connecting magnetic masses are not indispensable.

In a study of the properties of a long row of short cylinders, separated by gaps, it is found that the law according to which the apparent intensity of magnetisation diminishes with increase of the gap width is analogous to the law of variation of intensity of magnetisation of a ferro-magnetic substance with temperature in the region of the Curie point. The effect produced by rise of temperature, viz. change from ferro- to para-magnetism, may therefore be explained by a gradual separation of the elementary magnets, the latter having a strong demagnetising field. The paper is well illustrated by tables and curves.
G. E. A.

566. *The Magnetic Work of the Carnegie Institution.* **C. Chree.** (Nature, 110. pp. 94–95, July 15, 1922.)—A review of Vol. IV of the Researches of the Department of Terrestrial Magnetism (Land Magnetic Observations, 1914–1920) by Dr. L. A. Bauer.

567. *Magnetic Observations in France.* **A. Baldit.** (Comptes Rendus, 175. pp. 827–829, Nov. 6, 1922.)—Magnetic determinations made under the auspices of the French Committee of the international geophysical union in the south of France are tabulated. The secular changes between 1896 and 1922 for stations of the same group are sensibly constant. In the Haute-Loire the declination is anomalous over the volcanic portion of the region, whereas it is normal where there is a granitic terrain. W. A. R.

568. *A Rapid Process for Determining the Elements of Terrestrial Magnetism.* **A. Perot.** (Comptes Rendus, 175. pp. 869–872, Nov. 13, 1922.)—The principle of the apparatus devised by the author is based on the existence of induction currents in a coil rotating in the terrestrial field and on the quenching of these currents by generating, in the region of rotation, a suitable magnetic field in opposition to the terrestrial field and due to two rectangular coils. The instrument comprises a rotating coil which can attain 200 revolutions a second. When it rotates in the terrestrial field an alternating current is generated of which the frequency equals the number of revolutions. A coil C, wound on a concentric cylinder exterior to that which carries the moving coil, is fixed in any azimuth. By the reaction of the rotating coil an electromotive force is generated in the fixed coil of a frequency double that of the current in the moving coil. This coil C is connected up to a telephone. The compensation of the terrestrial field is effected by continuous currents sent into two coils B_1, B_2, wound on the same cylinder as coil C. The plane of the right section of B_1 is horizontal, that of B_2 vertical. The distribution of the conductors at the surface of the cylinder is sinusoidal for both windings. The most convenient method of determining the magnetic elements appears to be to determine the components of the field in two rectangular planes and then to regulate the intensities of the current so as to extinguish the sound of the telephone for two rectangular positions of the apparatus. The details of the process are subjected to mathematical analysis. The operation itself can be carried out in ten minutes, only four current intensities having to be measured (employing the potentiometer method). With a laboratory apparatus and simple milliammeters the following values were obtained at Meudon in a building containing iron girders: Inclination = 63° 57′, total force = 0·55 c.g.s. In the Paris laboratory, where the field varies constantly, the dipping needle gave 64° 47′, the apparatus 64° 50′. The method has the advantage of having no apparatus with sliding contacts, of doubling the frequency of the current induced by the terrestrial field, thereby producing a very audible sound, and of giving results which are but slightly affected by masses of iron in the vicinity of the apparatus, these latter not being exposed to the influence of a magnetised bar. By reason of its rapidity it is especially suitable for investigators possessing wireless telegraphy apparatus. E. F.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

569. *Adsorption of Salts at Metal Surfaces.* **H. v. Euler and G. Zimmerlund.** (Arkiv f. Kem. Min. and Geol. Stockholm, 8. No. 14, pp. 1–23, 1921–1922.)—Measurements of the amounts of silver nitrate and potassium chloride adsorbed from aqueous solution by finely divided gold and by gold leaf show that the quantity adsorbed increases with the concentration of the salt solution; the increase is at first linear, but subsequently tends to reach a maximum. The greatest quantity of silver ions adsorbed is more than sufficient to form a layer of unimolecular thickness on the surface of the gold. With the object of investigating the equilibrium, liquid mercury $\rightleftharpoons$ mercury salt solution, preliminary experiments have been made with mercury dropping through calomel solution, the amount of mercury in solution being ascertained by determining the poisonous effect exerted on amylase. The adsorption in this case exceeds that occurring with gold in silver nitrate solution.

Measurement of the velocities of efflux of mercury into mercuric nitrate solutions of different concentrations shows that the volume of the mercury drop varies enormously with the concentration of the mercury ions in the solution, namely, from 0·324 c.mm. for pure water to 0·001 c.mm. for 0·007 N and to $\frac{1}{\infty}$ for 0·008 N mercuric nitrate.

T. H. P.

570. *Properties of Powders. Part* II. *Expansion and Shrinkage during Caking of Potassium Carbonate.* **T. M. Lowry and E. E. Walker.** (Faraday Soc., Trans., 18. pp. 78–81, Oct., 1922.)—A sample of potassium carbonate, kept for some years in a paper bag and then emptied into a jar without ramming, underwent expansion to such an extent that the walls of the jar were fractured five days later. When subsequently left in an unheated room during winter for three weeks, the block of salt shrank to less than its original diameter. All attempts to reproduce either of these phenomena have met with failure. The expansion is possibly connected with the conversion of the sesquihydrated into the dihydrated carbonate. The density of the sesquihydrate is found to be 2·155 grms. per c.c. at ordinary temperatures. T. H. P.

571. *Properties of Powders. Part* III. *Powdering of Minerals by Decrepitation.* **T. M. Lowry and L. P. McHatton.** (Faraday Soc., Trans. 18. pp. 82–86, Oct., 1922.)—The marble-like barytes from Cumberland, Westmoreland, etc., decrepitates well when heated, whereas the comparatively soft, earthy Derbyshire barytes shows no decrepitation, and that from Devonshire exhibits intermediate behaviour. Decrepitation may be utilised to separate barytes from blende, galena, pyrites, and quartz, as well as from country rock. This decrepitation of barytes, like that of water-soluble salts, such as lead nitrate, may be attributed to the presence of included water; clear fragments are obtainable which are completely resistant to decrepitation by heat, and a semi-quantitative relationship exists between the water-content of barytes and the fineness of the powder produced by decrepitation. Similar relationships between water-content and extent of decrepitation are observed with celestine, crocoite, and common salt. T. H. P.

572. *Properties of Powders. Part* IV. *Grading of Powders by Elutriation.* **T. M. Lowry** and **L. P. McHatton.** (Faraday Soc., Trans. 18. pp. 23–31, Oct. 1922.)—The results are given of experiments made to determine the diameter of the particles of barytes and of quartz which are just lifted by a vertical flow of water with a velocity of 4, 5, 6, 7, and 8 mm. per second. The grading is found to be much more exact in a tube having a bore of 27 mm. than in one with a bore of 13 mm., the critical diameter of the particles being also about 5 % greater in the narrow than in the wide tube. This critical diameter decreases as the temperature rises, the temperature-coefficient being 0·4 % per degree. The relationship between critical diameter and velocity of water flow is expressed by the formula, $\log d = \bar{2}\cdot 67 + kv$, k being a constant depending on the diameter of the tube and the temperature of the water. Under identical conditions the diameters are 1·42 times as great for quartz as for barytes, the sectional areas being, therefore, in the ratio, 2 : 1, which is practically identical with that of the gravitational forces on the particles. The lifting power of the water is hence proportional to the area of the particle. T. H. P.

573. *Properties of Powders. Part* V. *New Elutriator for Rapid Use.* **T. M. Lowry.** (Faraday Soc., Trans. 18. pp. 32–33, Oct., 1922.)—When an ordinary elutriator is used, it is necessary to remove and weigh the minute residue of coarse material remaining in the apparatus. To overcome this inconvenience, a modification of Boswell's elutriator has been devised which renders it possible to estimate this residue approximately from its volume. The lower portion of the vertical tube of the apparatus is tapered smoothly from 25 to 2 mm. and is sealed on to a 2-mm. capillary tube about 100 mm. in length; this capillary carries a tap instead of a screw-clip. A weighed quantity of the powder is introduced into the empty tube of the elutriator, the tap being opened and elutriation, which may be greatly accelerated by tapping the rubber tube through which the water enters, continued for at least 20 minutes. The velocity of flow of the water should be low at first and should be increased to its normal value only after most of the fine matter has been carried away; this may be effected readily by means of the tap. The gritty residue is finally allowed to settle in the capillary tube, which is tapped repeatedly until the height of the column of grit remains constant. A few gravimetric determinations with a Gooch crucible provide data allowing these heights to be converted directly into percentages of residue. T. H. P.

574. *Properties of Powders.* (Faraday Soc., Trans. 18. pp. 57–77, Oct., 1922.)—This is a discussion on papers in the four previous abstracts. The importance of a knowledge of the degree of fineness of a powder in the manufacture of paints, enamels, photographic materials, fireclay, cocoa, etc., is emphasised. **A. W. Porter** shows that the law governing the connection between the velocity of flow of the water and the diameter of the particle is of the form, $d^3 = \frac{\mu^2}{\rho^2 g} . \mathrm{F}\left\{\frac{d}{\mathrm{D}}, \frac{\rho v^3}{\mu g}\right\}$, where d is the diameter of particle, D the diameter of the elutriator tube, ρ the

density difference, μ the viscosity, g the acceleration due to gravity, v the velocity of flow, and $F\{\ \}$ any function of the two ratios within the brackets. If a simple power law is assumed as a first approximation, the experimental data correspond nearly with the equation—

$$d^3 = \left(\frac{d}{D}\right)^K \frac{\mu^2}{\rho^2 g}\left(\frac{\rho v^3}{\mu g}\right)^n$$

Where $K = \frac{1}{11}$ and $n = \frac{2}{3}$; thus, other conditions being constant, the diameter of the particle varies nearly as the $\frac{2}{3}$-power of the velocity flow of liquid. T. H. P.

575. *On the Possible Existence of Metallic Compounds in the Vapour State.* **A. Eucken** and **O. Neumann.** (Zeits. Elektrochem. 28. pp. 322–324, July 1, 1922.)—It is pointed out that the existence of metallic compounds in the gaseous state would be of interest from the point of view of homopolar compounds. Experiments of H. v. Wartenberg (Zeits. Elektrochem. 20. p. 444, 1914) point to the existence of the compound Na_3Hg in a gaseous state; this according to the authors is improbable. To obtain evidence as to the existence in the vapour form of sodium amalgam, a mixture of sodium and mercury is distilled (the mercury being always in excess), and the boiling-point of the composition of the mixture and vapour is determined for a succession of stages in the distillation. It is concluded from the results that there is no evidence of the existence of a compound of sodium and mercury in the vapour state. T. B.

576. *Ozone. Micro-Analysis for Explosive Substances.* **E. H. Riesenfeld** and **G. M. Schwab.** (Ber. deut. Chem. Gesell. 55. pp. 2088–2099, July, 1922).—The use of micro-analyses of a few mgr. is recommended for the study of explosive substances like ozone. Electrolytic oxygen (from sulphuric acid) is ozonised by the silent discharge and is condensed in small spherical bulbs provided with long capillaries immersed in liquid air; the apparatus is described. By fractionation the ozone is enriched. The blue colour of pure liquid ozone is so intense that the bright filament of a glow lamp cannot be seen through 0·2 mm. of this ozone. The purity and the correctness of the ozone formula O_3 are shown by the volume relation oxygen/ozone and confirmed by the determination of the molecular weight after Dumas. The existence in ozone, at any rate in gaseous ozone, of oxozones is thus improbable. The density of ozone at − 182° C. is 1·784, that of oxygen at the same temperature 1·17; the melting-point of ozone is − 250°, the boiling-point − 112·4°, the critical temperature − 5° C. Ozone is very sensitive to violent changes of pressure, and the explosibility is much increased by the presence of certain catalysts, notably ether vapours; yet ozone can be kept for weeks. According to Nernst, ozone formation by heat should require a minimum temperature of 4000°; some ozone is formed when oxygen mixtures are exploded at that temperature, but not at 2000°. H. B.

577. *A Study of Explosions of Gas Mixtures.* **A. P. Kratz** and **C. Z. Rosecrans.** (Univ. of Illinois Eng. Exp. Sta., Bull. No. 133 [104 pp.], Aug., 1922.)—The object of the tests recorded was a study of the physical phenomena involved in the explosions of various mixtures of illuminating gas (from the city mains) and air. This includes the determination of the effect of the shape of the explosion vessel, and of turbulence at the time of ignition, as well as the study of the heat loss from the burning mass of gas. The chemical changes involved have not been considered. The principal measurements made were of "Maximum pressure attained," and "Time of explosion" for mixtures of gas and air in different proportions. Both these quantities were obtained from mechanically constructed curves. The recording mechanism consisted of a beam of light reflected from a concave mirror on a diaphragm indicator and focused on a strip of photographic paper carried on a revolving drum. The moving parts were very light, and the effect of inertia was almost entirely eliminated. It was found that a ratio of air to gas of about 4 to 1 gave the maximum explosion pressure and minimum time of explosion. In general the effect of turbulence (produced by allowing a fan to run while the explosion took place) was to increase the maximum pressure and decrease the time of explosion. The shape of the explosion vessel was also an important factor, the order of efficiency being (1) hemispherical; (2) cylindrical; (3) conical; (4) L-shaped; all these vessels having a volume of 155 cu. in. A historical review of the principal researches in the subject from 1810 to 1921 is given in an appendix, with special reference to the work of Dugald Clerk, Grover, Petavel, Bairstow, Horseley, Alexander, Hopkinson, Nagel, Bone, and David. T. B.

578. *Thermal Decomposition of Chlorine.* **F. A. Henglein.** (Zeits. anorg. Chem. 123. pp. 137–165, Aug. 8, 1922.)—Since chlorine is very corrosive at high temperatures, H. v. Wartenberg and the author (see also Ber. deutsch. Chem. Gesell. 55. pp. 1003–1006, 1922) study the dissociation of the chlorine molecule at lower temperatures by reducing the gas pressure to 10^{-5} atmos. in a double-walled quartz bulb, evacuating the jacket space. The gas pressure is observed by means of a Haber-Kerschbaum thread manometer [Abs. 234 (1915)]. The apparatus was first used for bromine between 700° and 900°. The chemical constant of chlorine is determined in three ways, by the method of O. Stern, and from the reactions between silver and chlorine and between mercury and chlorine; the values found are 0·68, 0·93, 1·5. A linear relation holds for Cl, Br, I between the heat of dissociation and the atomic radius and other constants. The electronic affinity of chlorine is calculated to be 73 cal. H. B.

579. *Experimental Test of v. Smoluchowski's Theory of the Kinetics of the Process of Coagulation.* **J. N. Mukherjee** and **B. C. Papaconstantinou.** (Phil. Mag. 44. pp. 305–320, Aug., 1922.)—The mathematical theory advanced by v. Smoluchowski to explain the kinetics of the coagulation of colloidal solutions (Zeits. phys. Chem., 1917, 92. p. 129) is discussed. The change in colour of gold sols produced on addition of an electrolyte (cf. Chem. Soc., J. 117. p. 1563, 1920) is utilised by the authors as a means of testing this theory. As the absorption coefficient in the red region is found to vary continuously with the coagulation, it is considered that a definite value of the absorption coefficient for a fixed wave-length (683 $\mu\mu$) may be regarded as representing a definite stage of the coalescence. From the results previously obtained (*loc. cit.*) and those now given, together with certain results of other observers, it is shown that the ratios of the times required to reach the same absorption coefficient with different electrolytes are independent of the time or of the stage of coalescence. These data hence constitute the best evidence so far recorded in favour of von Smoluchowski's theory; the magnitude "T" is undoubtedly a constant in the case of gold sols within the limits of coagulation. T. H. P.

580. *Magnetic Analysis of the Stannic Acids.* **P. Pascal.** (Comptes Rendus, 175. pp. 1063–1065, Nov. 27, 1922.)—Having shown (*ibid.* pp. 814–816) that the three types of hydrated silica magnetically examined behaved like gels or mixtures of anhydrous SiO_2 and water, and that they do not contain any definite silicic acid, the author finds that the so-called stannic acids have an analogous constitution. Determining the magnetic susceptibility of sodium stannate $SnO.(ONa)_2.3H_2O$, of the methyl stannonic acid $CH_3.SnO.OH$ and of tin, which are respectively -986, -540, -299, all in 10^{-7} units, the author calculates the theoretical specific susceptibilities of $SnO.(OH)_2$ and $SnO.(OH_4)$ which gave the values $-2{\cdot}77$ (or $2{\cdot}79$) and $-3{\cdot}21$ (same units). Preparing the three so-called stannic acids (ortho, meta, para) by various methods, he finds that none of them have these calculated magnetic susceptibilities, but that the observed values agree with $SnO_2.nH_2O$. The stannic acids are therefore merely hydrogels, as van Bemmelen had suggested. H. B.

581. *The Physical Chemistry of Dyeing. Acid and Basic Dyes.* **T. R. Briggs** and **A. W. Bull.** (J. Phys. Chem. 26. pp. 845–875, Dec., 1922.)—The process of dyeing wool with acid and basic dyes is investigated from the standpoint of the adsorption theory of dyeing as formulated by Pelet-Jolivet and Bancroft. It is shown that the taking up of dyes is a case of adsorption, and that the amount of dye adsorbed varies continuously with a change in the hydrogen ion concentration of the dye bath. W. R. C.

582. *Liesegang Rings* (1) *and* (2). **E. C. H. Davies.** (Am. Chem. Soc., J. 44. pp. 2698–2704, and 2705–2709, Dec., 1922.)—The formation of Liesegang rings of silver chromate in gelatin and the effects of gravity on the rate of diffusion upward during the formation was studied. The factors governing the formation of rhythmic bands of dyes on filter paper were investigated. Several varieties of filter paper were used, the dyes, 62 in number, were used in solutions of 0·04 % and 0·05 %. It was found that uniform temperature and a gradual decrease in the rate of flow are the important factors in the formation of the bands. F. J. B.

583. *Determination of Complex Formation in Aqueous Solutions of Copper Salts by Means of Permutit.* **A. Günther-Schulze.** (Zeits. Elektrochem. 28. pp. 89–99, Feb. 1, 1922. From the Reichsanstalt.)—The discordant results of freezing-point depressions and conductivity measurements, as well as the changes with concentration of the transference numbers of the ions, of colour and of electric potential, observed in the case of aqueous solutions of copper salts, have been ascribed to the formation of hydrated and complex ions, mostly anions probably. The author investigates the problem by the aid of potassium permutit, which consists of a rigid skeleton of the anions

$(\mathrm{OAl_2O_3 \cdot 3SiO_2 \cdot 5H_2O})''$ and of easily removable kations 2 $\mathrm{Me}^{\cdot}_1$ (in this case Me = K). When permutit is brought into an aqueous solution which contains any free ions $\mathrm{Me}^{\cdot}_2$, these kations will enter into the permutit and replace $\mathrm{Me}^{\cdot}_1$ until equilibrium is established. Shaking various copper salt solutions with permutit, the author determines the decrease in the solution of the percentages of copper and of acid and the increase of potassium. He finds that the simple complex ions $\mathrm{CR}^{\cdot}$, where R is a monovalent acid radicle, are present in almost all the salt solutions, even at the highest dilution; the presence of the higher complexes $\mathrm{Cu_2R}^{\cdot}_3$ is proved only for $\mathrm{CuCl_2}$ and $\mathrm{CuBr_2}$, though it is probable also in other cases. For equal concentration the complexity increases with the strength of the acid, and is greater with the halogen salts than with the salts of the oxygen acids (acetate, formate, sulphate, nitrate, chlorate).
H. B.

584. *Determination of the Dissociation of Bivalent Chlorides in Aqueous Solutions by Means of Permutit.* **A. Günther-Schulze.** (Zeits. Elektrochem. 28. pp. 387–389, Sept. 1, 1922. From the Reichsanstalt.)—The experiments are made as in the preceding abstract by shaking the solutions, either of normal or of very high concentrations, for about 4 days with 3 g. of ammonium permutit; the latter permutit was chosen by preference to the potassium compound in order to facilitate the analyses. At the highest concentrations most solutions of bivalent chlorides contain $\mathrm{MeCl}^{\cdot}$ ions in considerable quantities; in the case of Mg, Ni, Cu, higher complexes are also present. The first dissociation stage of $\mathrm{MeCl_2}$ into $\mathrm{MeCl}^{\cdot} + \mathrm{Cl}'$ preponderates, in concentrated solutions, the more over the complete dissociation into $\mathrm{Me}^{\cdot\cdot} + \mathrm{Cl}' + \mathrm{Cl}'$, the smaller the ionic radius of the kation of the metal. As the dilution is increased, the first stage becomes less noticeable. In N concentrations the presence of $\mathrm{MeCl}^{\cdot}$ ions can no longer be proved in the case of large ions; in the case of the smallest ions (Ni, Cu) these $\mathrm{MeCl}^{\cdot}$ ions may make up as much as ½ of the total ions. The larger, therefore, the ion, the less able will it be to attach to itself acid radicles, water molecules, and salt molecules, constant valency being presumed. The experiments concern the chlorides of Ba, Sr, Ca, Mg, Zn, Cd, Mn, Co, Ni, Cu.
H. B.

585. *Possible Modification of the Cementite Diagram.* **L. Grenet.** (Comptes Rendus, 175. pp. 1067–1070, Nov. 27, 1922.)—Besides the transformation points A_1, A_2, A_3, Ball and others found a point A_4 near 1400° at which, according to Westgren and Phragmén [Abs. 2342 (1922)], the A_3 transformation is reversed. At A_1, the α phase of the eutectic passes into $\alpha + \gamma$ (cementite); A_1 does not exist in pure iron and hardly in carbide iron when silicon is present. A_2 corresponds to the ferromagnetic point of Curie and does not involve any phase change. In pure iron phase changes occur only at A_3 and A_4. At A_3 pure iron passes from the α into the γ phase, at A_4 γ into δ. In a vacuum the $\alpha-\gamma$ change of electrolytic iron extends over a range of 25°; when the metal is well freed of gas, the transformation temperature is raised by 20°, though the gases are not entirely expelled at a red heat. After being heated to 900°, electrolytic iron yields large α crystals, but not if heated to 1000° or to 950° for long periods (Stead and Carpenter); rigorously pure iron would probably change into γ iron below 1000°. With temperature rising from

808° to 885° and 912°, the coefficient of magnetisation (× 10) of soft iron decreases from 655 to 119 and 45, and this is analogous to the decrease in the carbon percentage (× 2000): 500, 140, 60. Hence Charpy and Grenet proposed in 1903, that the $\alpha - \gamma$ transformation might be complete near 950°. It would then appear that the slight impurities, always present in iron, would explain the difference between the diagrams of strictly pure iron and of other iron, and the now proposed diagrams for steel would be identical with that of copper alloys. It would thus be illogical to consider that steel differs from other alloys owing to the transformations of the metal iron. H. B.

586. *Relation between the Equilibrium Diagram and the Hardness in Binary Alloys.* **T. Isihara.** (Tôhoku Univ., Sci. Reports, 11. pp. 207–222, June, 1922. Thirty-sixth Report from the Iron and Steel Research Inst. In English.)—Shore hardness tests are carried out in the annealed condition, and after quenching from a series of high temperatures on alloys of the binary series Ni-Cu, Fe-Cu, Zn-Al, Cu-Sn, Cu-Al, the results being tabulated and plotted. Tammann's theory, that in a series forming a continuous solid solution the hardness of one component increases with each addition of the other to it, with a maximum at equal atomic proportions, is supported. In such a series, the effect of quenching on hardness is very small. Where a series forms a solid solution with limited miscibility, the effect of quenching on the hardness is small in the case of the homogeneous alloys. If the quenching temperature lies above a eutectoid point, or above the solubility line, the hardness curve changes abruptly. The hardness of an annealed eutectoid alloy has a maximum value compared with neighbouring concentrations. An intimate relationship is shown to exist between the hardness and the equilibrium diagram, so that ambiguous parts in the diagram can be determined by hardness measurements. A. B. C. L.

587. *Transformations in Bronze, Aluminium Bronze and Brass.* **T. Matsuda.** (Tôhoku Univ., Sci. Reports, 11. pp. 223–268, Sept., 1922. In English.)—In the cases of bronze and aluminium bronze changes occur at 530° to 505° C. and 560° C., respectively. These are eutectoid transformations, and are confirmed by thermal analysis, micro-examination, and changes in length, electrical resistance, thermal e.m.f., and mechanical properties, with temperature. Quenching above the transformation point in each case increases the tensile strength and elongation and lowers the hardness. The fact that changes in the physical properties with temperature are, in the case of aluminium bronze, complicated, is accounted for by assuming the change to be stepped as in the A_1 transformation in steel (Honda). In the case of brass the change is held to be a progressive transformation, having the same nature as the A_2 transformation in iron. It is not a change of phase, but of atomic energy, and extends over a range of temperature, the upper limit being 480° C. This is corroborated by thermal analysis, thermal expansion, electrical resistance, thermal e.m.f., and mechanical properties. No change in microstructure is found. It is found that γ undergoes a transformation at 280° C. J. L. H.

588. *An Investigation of Duralumin.* **S. Konno.** (Tôhoku Univ., Sci. Reports, 11. pp. 269–294, Sept., 1922. Sixty-fifth Report from the Iron and

Steel Research Inst. In English.)—Describes a series of experiments made to determine the nature and effects of the transformation in duralumin. The softer the quenching the greater the immediate effect of quenching and the less the ageing effect and final hardness. The effect of quenching is due to the sluggish separation of copper and magnesium compounds, very slow cooling being required for complete separation. Mg_2Si plays the more important part in producing the effects of quenching. Silicon is present as an impurity in aluminium. Copper and manganese effect the hardness due to quenching, but not the ageing effect. The author concludes from the specific resistance-temperature curves that tempering of the quenched alloy occurs in two steps at 210° and 280°, respectively marking the partial separation of the copper-aluminium and the magnesium-silicon compounds. The effect of quenching, it is claimed, is exactly similar to the effect produced in low carbon steels severely quenched. J. L. H.

589. *Recent Progress in Microscopic Metallography and Macrography.* **L. Guillet.** (Rev. de. Mét. 19. pp. 614–625, Oct., 1922.)

590. *Solidification of the System $MgCl_2$-KCl-$BaCl_2$.* **J. Valentin.** (Comptes Rendus, 175. pp. 1061–1063, Nov. 27, 1922.)—The binary diagrams of the three salts, which give the two double salts $MgCl_2 . KCl$ and $BaCl_2 . 2KCl$, having been studied by Menge and others, the author investigates the ternary system by the apparatus of Rengade [Abs. 1323 (1909)]. The paper gives the plane diagrams and the triangular diagram, determining the 3 triple points with the aid of the intersections of the solidification surfaces with the vertical planes for the pairs of salt combinations. H. B.

591. *A Particular Class of Voltaic Cell.* **V. Karpen.** (Comptes Rendus 175. pp. 96–98, July 10, 1922.)—It appeared to the author that liquids are merely gases under high compression, and that gases under suitable pressure should therefore dissolve such bodies as metallic salts and be conductors of electricity. On this hypothesis he constructed a cell consisting of a block of copper, having a cylindrical cavity in it, 32 mm. in diameter and 35 mm. deep. In this cavity is placed a saturated solution of copper sulphate. A second block is then placed on the first so as to form a cover to the aperture, but is separated therefrom by mica, which apparently is perforated in the centre. The two blocks are placed together under hydraulic pressure, and thus the solution is in contact with one of the blocks, and any gas is in contact with the other, or with both. Since the blocks are otherwise insulated from one another, a voltaic cell is formed when the device is heated to a suitable temperature. It was found that an e.m.f. was noticeable between the temperatures of 250° and 350°, and that it reached a maximum of ¼ volt between 300° and 350°, the block in contact with the solution being positive; the internal resistance varied between 1000 and 20,000 ohms. On opening the cell it was found that a considerable deposit of electrolytic copper had taken place, but the deposit was not in proportion to the quantity of electricity generated. Other cells were constructed of a similar type, but operating at ordinary temperatures. They consisted of two non-miscible liquids containing a colloid or salt in solution, or a mixture of salts. For example, water and amyl alcohol containing zinc sulphate, with zinc electrodes, gave an e.m.f. of 0·7 volt. The view is expressed that these cells are not in accordance with the osmotic theory of Nernst, and that they contradict the second law of thermodynamics.

W. R. C.

592. *Temperature Coefficient of Electromotive Force of Galvanic Cells and the Entropy of Reactions.* **R. H. Gerke.** (Am. Chem. Soc., J. 44. pp. 1648–1704, Aug., 1922.)—The author describes accurate measurements of temperature coefficients of a number of galvanic cells. Values of the free energy change, the entropy change, and the change of heat content for certain reactions are calculated from the measurements of e.m.f. and of temperature coefficient. The third law of thermodynamics has been subjected to a more rigorous test. The entropies of gaseous chlorine and solid iodine have been calculated. W. R. C.

593. *Applications of Oxygen and Air Electrodes to Acidimetry and Alkalimetry.* **N. H. Furman.** (Am. Chem. Soc., J. 44. pp. 2685–2697, Dec., 1922.)—Experiments were made to apply the oxygen and air electrodes to the electrometric titration of acids and alkalies, in the presence of strong oxidising agents. A survey of the analytical applications of the oxygen electrode was made, and it was found that the oxygen electrode gives accurate results in the determination of total acidity or alkalinity.

In the presence of oxidising agents, an oxygen, air, or a simple platinised electrode was found to give satisfactory results in the determination of total acidity or alkalinity. For this the effects of alkaline chromates, or acidified dichromate were studied. F. J. B.

594. *Successive Electrometric Titration of Iron, Vanadium, and Uranium.* **R. G. Gustavson** and **C. M. Knudsen.** (Am. Chem. Soc., J. 44. pp. 2756–2761, Dec., 1922.)—The results obtained on analysing salts of iron, vanadium, and uranium, individually and in all possible combinations, by the electrometric method are shown in the form of curves and the conditions to be observed in all cases deduced. T. H. P.

595. *Electrometric Titration of Dichromate with Ferrous Sulphate.* **M[arion] Eppley** and **W. C. Vosburgh.** (Am. Chem. Soc., J. 44. pp. 2148–2156, Oct., 1922.)—The practical limits of acidity for the electrometric titration of dichromic acid with ferrous sulphate have been determined. The effect of dissolved air is negligible, and that of hydrofluoric acid is stated.

W. R. C.

596. *Activity Coefficient of Hydrochloric Acid in Aqueous Salt Solutions.* **H. S. Harned** and **N. J. Brumbaugh.** (Am. Chem. Soc., J. 44. pp. 2729–2748, Dec., 1922.)—In order to calculate the activity coefficients of hydrochloric acid in mixtures of solutions of hydrochloric acid and chlorides of both the alkali and alkaline-earth metals, measurements have been made at various temperatures of the cells $H_2 \mid MeCl_2(c)$ in $HCl(0{\cdot}1M) \mid HgCl \mid Hg$ and $H_2 \mid MeCl_2$ in $HCl \mid (0{\cdot}1M) \mid Sat.KCl \mid HgCl \mid Hg$ (where Me denotes Ba, Sr, or Ca); $H_2 \mid KCl(c)$ in $HCl(c_1) \mid AgCl \mid Ag$; and $H_2 \mid KCl(c)$ in $HCl(c_1) \mid HgCl \mid Hg$, containing acid at 0·01M and 0·001M. The data obtained are used to calculate the free-energy decrease and heat-content decrease of the cell reaction, the charges in partial molal free energy and heat content of hydrochloric acid in the mixtures, and the mean activity coefficients of hydrochloric acid in solutions of potassium, sodium, lithium, calcium, strontium, and barium chlorides. The value of F'_a, the mean activity coefficient of hydrochloric acid in the acid-salt mixtures containing acid at concentrations from 0·01M to 1M is expressed accurately by the formula, $\log F'_a = \alpha' c_1 - \beta' \mu^{m'} + \alpha''(\mu - c_1)$, where μ is the ionic strength and the other terms constants. With more dilute acid, the term $\gamma'\left(\frac{\mu - c_1}{c_1}\right)$ must be added, this being a function of the salt : acid concentration ratio. The effect represented by this term is probably due to increase in the activity of the hydrogen ion, and if, as is to be expected, the same phenomena is observed in mixtures containing other ions, it will be of importance in dealing with the problem of the solubility of sparingly soluble salts in solutions of other salts.

Evidence is obtained leading to the conclusion that, in solutions of strong bivalent chlorides at the same concentration and temperature, the chloride ion will have the same activity; also that the activity of the chloride ion in uni-univalent chloride solutions is greater than in bivalent chloride solutions of the same ionic strength. T. H. P.

597. *Degree of Ionisation of Ethyl Alcohol. I. From Conductivity Measurements.* **P. S. Danner** and **J. H. Hildebrand.** II. *From E.M.F. Measurements.* **P. S. Danner.** (Am. Chem. Soc., J. 44. pp. 2824–2831 and 2832–2841, Dec., 1922.)—Methods of purifying ethyl alcohol, and improvements in the construction of conductivity cells, are discussed. The conductivity method used by Kohlrausch and Heydweiller to determine the degree of ionisation of water is applied to the alcohol, a sample of alcohol being prepared with the specific conductivity $1 \cdot 35 \times 10^{-9}$ reciprocal ohms. From this the value of the dissociation constant is calculated to be $2 \cdot 89 \times 10^{-18}$, the fraction dissociated being $1 \cdot 0 \times 10^{-9}$. These results are based on the assumptions, neither strictly accurate, that all the conducting bodies present are the ions of alcohol and that these consist solely of H^+ and $C_2H_5O^-$; the value found for the degree of ionisation may hence be considerably too high.

In Part II the results are given of measurements of the e.m.f. of a series of galvanic cells in alcoholic solution, the cells being so chosen that the final result is entirely free from assumptions regarding liquid junction potentials. The experimental technique developed for handling highly reactive amalgams, and the design of electrode vessels of relatively low internal resistance, for use with dilute solutions, are described. The activity coefficients for hydrochloric acid in ethyl alcohol for a range of concentrations up to 0·3N are given. The dissociation constant of ethyl alcohol into H and C_2H_5O ions is calculated to be $7 \cdot 28 \times 10^{-20}$, the fraction dissociated being $1 \cdot 6 \times 10^{-11}$. T. H. P.

598. *Electrolysis of Chromate Solutions in a Diaphragm Cell.* **A. Lottermoser** and **K. Falk.** (Zeits. Elektrochem. 28. pp. 366–376. Sept., 1922.)—In the electrolysis of chromate solutions, the CrO_4'' ion is liberated at the anode and reacts with the Na_2CrO_4 to give $Na_2Cr_2O_7$. At the same time the Na· ion liberated at the kathode reacts to give NaOH. The OH′ ion thus produced migrates towards the anode together with, though at a greater rate than, the CrO_4''. Experiments were conducted with a glass rectangular cell which could be divided into two or three compartments by the insertion of diaphragm plates of porous porcelain fitted so as to form water-tight compartments. A thin platinum plate was used as anode and an iron plate as kathode. During electrolysis a rise in the level of the katholyte occurred through the migration of anolyte liquid by electro-osmosis. In some cases this was checked by employing a higher level of liquid in the kathode compartment at the commencement. Efficiency measurements were made at different intervals during the electrolysis of the yield of sodium hydrate at the anode and bichromate at the kathode with varying conditions. The current efficiencies began with values of 100 % and fell in proportion to the migration of OH′ ion into the anolyte. In experiments with a three-compartment cell, sodium chromate was used in both anode and intermediate compartments, while the kathode compartment contained either sodium chromate or hydroxide. The best yields with a two-compartment cell were obtained by the use of sodium chromate in both anolyte and katholyte. A still better yield was obtained with a three-compartment cell using sodium chromate throughout. Formulæ are deduced to enable the calculation of the yields in terms of concentrations, migration velocities, and rates of diffusion through the diaphragm. The process can also be carried out, though with a lower current efficiency, by means of the bell system in which no diaphragms are employed. J. N. P.

599. *Durability of Anode Carbon.* **K. Arndt** and **W. Fehse.** (Zeits. Elektrochem. 28, pp. 376–382, Sept. 1, 1922.)—In alkali chloride electrolysis anodes of Acheson graphite are used exclusively at the present time. Graphite cannot be separated quantitatively from amorphous carbon by chemical means. A determination of the graphite is made by grinding to a fine powder, grading to definite sizes by sieving, and compressing in a thick-walled porcelain tube between metal electrodes. The electrical resistance increases with the fineness of division of the particles and for a given size varies with, and thus serves as a measure of the graphite content. The chemical resistivity of the graphite was determined by using plates of the material as anode in the electrolysis of a solution of sodium chloride containing chromate. After subjecting to a definite current for a measured period, the loss of weight was determined. Analysis was made of the gases, which contained chlorine, oxygen, and carbon dioxide and the amount of the latter, together with the loss in weight of the electrode, was taken as a measure of the attack of the electrode. The resistance to attack was found not to depend entirely on the proportion of graphite, the greatest resistance being obtained with anodes with 75 % graphite. With a completely graphitised product the substance is liable to be somewhat porous, due to the fact that in the manufacture the more prolonged furnace treatment volatilises the mineral substance which acts as a cementing material for the granules of carbon while, at the same time, the smaller particles of graphite are converted into larger plates which are more readily disintegrated. The surface structure of anodes of different forms of carbon before and after electrolytic attack, is shown by means of microphotographs. [See Abs. 1317 (1921); 996B (1922).] J. N. P.

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